



**CITY OF AUSTIN
PUBLIC WORKS DEPARTMENT**

**PROJECT MANUAL
Contract Documents and Technical Specifications**

**VOLUME 3 of 4
Hornsby Bend BMP Centrifuges**

**C.I.P. PROJECT NUMBER: 3164.077
SOLICITATION NUMBER: CLMC872**

**CITY OF AUSTIN
Public Works Department
PO Box 1088
Austin, Texas 78767**

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SECTION 02050

FEB SLUDGE REMOVAL, CLEANING AND INSPECTION (ALTERNATE)

PART 1 GENERAL

1.01 WORK INCLUDED

- A. Upon acceptance of Bid Alternate 1, work includes pumping sludge, cleaning and inspection of the existing Flow Equalization Basin (FEB). This work includes, but is not limited to providing the following temporary systems and major work tasks:
1. Provide temporary pumping facilities to remove all liquid, grit, scum, rags, sludge, and foreign material from the FEB.
 2. Provide temporary dewatering facilities to dewater FEB contents. Collect all water from dewatering operations and pump or drain it to an OWNER approved process drain, manhole, or lift station on the plant site. The disposal point must be identified prior to starting dewatering operations.
 3. Transfer dewatered material by truck transport to an approved landfill site. Provide paint filter tests, lab analysis, etc. required by landfill for disposal of materials.
 4. Take samples of dewatered material and perform a detailed characterization of the grit quality.
 5. Pressure wash all interior wall and floor surfaces. Collect all water from pressure washing operations and pump it to OWNER approved process drain, manhole, or lift station on the plant site.
 6. Furnish a temporary boom lift or scaffolding structure(s) inside the FEB to allow all interior surfaces to be examined by the Owner's Representative.
 7. Provide all pumps, associated piping and bypass piping for temporary systems and perform all related operations to support the above work tasks.

1.02 FEB INFORMATION

- A. Information concerning FEB size, physical configuration, and features is provided below:
1. Construction: Partially buried cast-in-place concrete
 2. FEB Interior Diameter: 85 feet
 3. Straight Sidewater Height: 31.5 feet
 4. Floor Slope: 3.86:1, H:V
 5. Cone Depth: 11 feet
 6. Typical operating Depth: 16 feet (straight sidewater depth)
 7. Approximate Operating Volume: 835,000 gallons
 8. Removal Volume (based on 8 feet sidewater depth): 495,300 gallons
 9. Number of Top Access Hatches: One
 10. Number of Side Access Manholes: Two (one inside the FEB/Blending Tank building complex and one buried)
 11. Type of Cover: Column supported concrete flat cover

1.03 RELATED WORK

- A. The following Specification sections are referenced in this section and contain specific technical requirements related to the work or requirements related to the CONTRACTOR's execution of this work.
 - 1. Section 01015 – Construction Coordination and Sequencing
 - 2. Section 01025 – Measurement & Payment Lump Sum Contracts
 - 3. Section 01030 – Alternates
 - 4. Section 01300 – Submittals
 - 5. Section 01380 – Construction Photography & Videos
 - 6. Section 01500 – Temporary Facilities

1.04 HEALTH AND SAFETY

- A. In confined space environments, as defined in 29CFR 1910.146, the Work shall comply with the requirements set forth by Federal OSHA applicable to the construction industry. The CONTRACTOR shall provide and require use of safety and personnel life-saving equipment for persons working in Confined Space areas, including but not limited to, adequate forced ventilation, body harnesses, and gas detection meters that continually monitor for levels of oxygen, hydrogen sulfide, carbon monoxide, and Lower Explosion Limit (LEL).
- B. The CONTRACTOR shall provide all head and face protection equipment and respiratory devices required to safely perform the work specified herein. Equipment shall include any applicable masks recommended by the manufacturer while performing blasting or application of the coating materials.
- C. Use of ear protection devices shall be provided and required by the CONTRACTOR whenever the occupational noise exposure exceeds 29CFR 1910.95 limits.
- D. Failure to comply with health and safety laws, regulations, codes, permits, and Standard Operation Procedures will be grounds for shutting down the Work. All costs resulting from a shutdown of the Work that are due to the CONTRACTOR's negligence or failure to comply with applicable safety requirements shall be borne by the CONTRACTOR. After a shutdown of the Work, the Work will not be permitted to begin again until the OWNER and / or ENGINEER is satisfied that all necessary health and safety precautions are being taken.
- E. Flammable or volatile solvents in coating system components constitute a hazard with regard to fire and explosions wherever flame or spark exposure is possible. All flames, smoking, and welding, etc., are strictly prohibited in Work or storage areas. Fire abatement devices shall be readily available and in operating condition. Necessary precautions shall be taken to keep fire hazard to a minimum; all oily rags, waste, and other combustibles not in covered containers shall be removed from the area daily. All flammable products shall be stored in conformance with applicable State, County and Local Fire Codes pertaining to flammable materials.

- F. The coating project shall never exceed the current VOC limits set by TCEQ Chapter 115.453. The CONTRACTOR shall be responsible for all fines or legal costs resulting from any VOC limit violations.

1.05 PROTECTION OF THE ENVIRONMENT

- A. Comply with the requirements of Section 01500, Temporary Facilities and the following specific requirements.
- B. The CONTRACTOR's operations shall in no way contribute to air, water, or land pollution, including such nuisances as odors, insects, noise, surface or groundwater contamination, or any other condition that would have a detrimental effect on the environment. The CONTRACTOR shall meet all local, state and federal regulations for handling and disposal of the sludge material.
- C. Hauling operations shall be limited to Monday through Friday, 7:00 a.m. to 7:00 p.m., local time, unless otherwise approved in writing by the OWNER. Likewise, CONTRACTOR forces shall not work during City holidays or weekends.
- D. The CONTRACTOR shall be responsible and take necessary precautions to control and prevent nuisance odors from leaving the plant site during cleaning and sludge removal operations.
- E. The CONTRACTOR shall be responsible and take necessary precautions to control and prevent liquid from leaking.

1.06 SUBMITTALS

- A. Submittals shall be made in accordance with Section 01300 – Submittals and the following specific requirements.
 - 1. Quality Assurance Submittals
 - a. Bypass Piping Plan that includes, at a minimum, details of the following:
 - (i) Connection locations
 - (ii) Piping Layout
 - (iii) Pipe material
 - (iv) Pipe size
 - (v) Location of valves
 - (vi) Method of installation
 - b. Sludge Removal Pumping & Dewatering Plan that includes, at a minimum, details of the following:
 - (i) Layout, including:
 - (a) Connection locations
 - (b) Pump layout dimensions, including offset distance from existing facilities / buildings
 - (c) Piping layout
 - (ii) Pump parameters, including:
 - (a) Number of pumping units

- (b) Manufacturer and model
 - (c) Capacity and flow rates
 - (d) Power requirements
- (iii) Piping and valve information, including:
 - (a) Pipe material
 - (b) Pipe size
 - (c) Location of valves
 - (d) Method of installation
- (iv) Electrical and instrumentation plan, including:
 - (a) Temporary power supply from Austin Energy
 - (b) Temporary instrumentation and control (as required)
- (v) Pressure calculations, including:
 - (a) Total Dynamic Head (TDH) of line
- (vi) Thrust harness and joint restraint sizes and location (if required)
- (vii) Temporary pipe supports and anchoring required
- (viii) Method of noise control for each pump
- (ix) Manufacturer recommended spare part and tools to have on site for pumps and dewatering equipment
- (x) Schedule for installation and maintenance of pumping and dewatering system
- (xi) List of designation and qualifications / experience of Responsible Persons for pumping and dewatering system installation and maintenance.
- (xii) Description of high pressure indication unit and shutdown procedure
- (xiii) Site-specific Emergency Response Plan, including:
 - (a) Responsible Person's names, qualifications, experience, contact information and notification procedures
 - (b) Provisions to ensure prompt repair and restoration of service in the event of electrical or mechanical failure
 - (c) Spill containment, cleanup and disinfection procedures including equipment and material types, quantities, locations and procedures for deployment
 - (d) Procedures, including names and contact information, for notification of OWNER and applicable regulatory agencies in the event of a spill
- c. Sludge Disposal Plan that includes, but is not limited to, the following:
 - (i) Removal methods
 - (ii) Concentration methods
 - (iii) Transportation methods
 - (a) Name of hauling contractor
 - (b) Copy of license for hauling contractor for proof of acceptability
 - (iv) Disposal methods
 - (a) Testing methods for landfill disposal
 - (b) Methods and frequency of paint filter testing

- (v) Equipment requirements
 - (vi) Accidental spill cleanup plan
 - (vii) Wet weather operations
 - (viii) Odor control provisions
2. Health and Safety Plan
- a. The Health and Safety Plan shall include, at a minimum, the following:
 - (i) A list of all safety and personnel life-saving equipment for persons working in Confined Space areas per the requirements stated herein
 - (ii) A list of all head and face protection, respiratory devices and ear protection devices per the requirements stated herein
 - (iii) A plan for scaffolding and ladder Fall Protection in accordance with 29CFR 1926.502 and the requirements stated herein
3. Disposal Records: Copies of all disposal records shall be submitted to the OWNER and shall include, but not be limited to, the following information on a daily basis:
- a. Date of disposal
 - b. Sludge volume
 - c. Percent of total solids
 - d. Total dry weight
 - e. Detailed characterization of grit quality
 - f. Method of disposal
 - g. Name of disposal site and location
 - h. Receipts from disposal site operator
 - i. Driver's signature
 - j. Signature of CONTRACTOR or Contractor's Representative designated at the Preconstruction Conference
4. Allowance Submittals (As Applicable)
- a. Miscellaneous Concrete Repair
 - (i) Schedule of Demolition, Plan of Repair, Manufacturer's technical literature and all other submittal requirements of Section 03740 – Concrete Repair and Modifications.
 - b. Miscellaneous Concrete Coating Repair
 - (i) Coating Manufacturer's product data sheet for each coating type, including surface preparation requirements, recommended spreading rates, application procedures, recommended primers, environmental limits (temperature, humidity and dew point) and other instructions.
 - (ii) Material Safety Data Sheets (MSDS) for all coatings, solvents, etc.
 - (iii) Applicator's Qualifications
 - (iv) Coating Manufacturer's statement regarding applicator instruction on product use and application.
 - (v) Coating Manufacturer's written warranty.
- B. Prior to the start of any WORK, the CONTRACTOR shall establish with the INSPECTOR schedules and notification procedures to ensure all surface preparation WORK has been inspected prior to the application of any coating. These procedures shall remain in effect

for the duration of the coating project. Under no circumstances shall any surfaces be coated without prior approval of the INSPECTOR. Coatings applied without the INSPECTOR's authorization shall be removed and reapplied at the sole expense of the CONTRACTOR.

1.07 SITE INFORMATION

- A. Non-potable water (NPW) is available for use on site. The closest NPW source is near the existing scrubber.
- B. Power is NOT available from the OWNER's existing power distribution system.

PART 2 PRODUCTS

2.01 GENERAL

- A. Specific products for sludge removal and cleaning are not required. Use heavy duty, industrial quality equipment and materials as necessary for complete sludge/content removal, FEB cleaning, dewatering of sludge/contents as well as transportation and disposal of dewatered sludge/contents.

2.02 PUMPING UNITS

- A. All pumps used shall be self-priming units that do not require the use of foot-valves or vacuum pumps in the priming system. The pumps shall be electric powered. All pumps must be constructed to allow dry running for long periods of time to accommodate the cyclical nature of flows.
- B. The CONTRACTOR shall provide the necessary manual start / stop controls for each pump.
- C. The CONTRACTOR shall include one standby pump of each size to be maintained on site.
- D. In order to prevent accidental spillage of flows, all discharge piping shall be temporarily constructed of pressure pipe with positively restrained joints. Under no circumstances will aluminum "irrigation" type piping be allowed. Glued PVC pipe shall be allowed for diameters 2" or less. Glued PVC pipe is not allowed for diameters greater than 2".
- E. CONTRACTOR shall provide a high pressure indicator for automatic shutdown to prevent sludge line/connection failure.
- F. Each pumping unit to include a run time meter.

PART 3 EXECUTION

3.01 GENERAL

- A. The sludge removal and cleaning of the FEB shall take no longer than thirty (30) calendar days as the FEB is an integral part of the Hornsby Bend Biosolids Treatment Plant processes.

- B. The CONTRACTOR shall comply with all applicable local, State and Federal laws, codes, ordinances, and regulations.
- C. The CONTRACTOR shall furnish all labor, materials, equipment, tools, and incidentals necessary to remove all liquid, grit, scum, rags, sludge, and foreign material from the interior of the FEB, and transport and dispose of removed material. The CONTRACTOR shall obtain and pay for necessary permits, fees, inspections, testing, etc.
- D. Provide all items necessary for workers to perform any work inside the FEB in a safe manner. These items must comply with all Federal, State, and local worker safety requirements for working in a hazardous confined space. The work area is corrosive with potential for low to no oxygen, presence of hydrogen sulfide, and presence of methane, which creates an explosive environment. CONTRACTOR shall provide ventilation system capable of providing enough air changes per hour to maintain normal atmospheric concentrations of oxygen while workers are present inside the FEB. CONTRACTOR should provide an emergency escape plan for workers if ventilation system operation is interrupted. In the area of the FEB, the CONTRACTOR shall post and rigidly enforce "No Smoking" on the site and shall conduct his operations to prevent explosion.
- E. The CONTRACTOR must have written approval from OWNER 45 days prior to shutdown/isolation of the FEB for cleaning and inspection.

3.02 BYPASS PIPING

- A. The CONTRACTOR shall provide a gravity bypass from the Headworks effluent to the Blend Tank throughout the duration of the FEB sludge removal, cleaning and repair as specified herein.
- B. Required Connections
 - 1. Upstream of FEB
 - a. Connection will be required on the effluent line from the Headworks structure as well as the existing bypass line.
 - b. The Headworks bypass shall be maintained throughout the duration of the pumping and the connection shall be valved for use when pre-determined.
 - c. Both lines will be piped into one temporary line.
 - 2. Discharge Into Blend Tank
 - a. Discharge connection into the blend tank shall take place at the existing 18-inch blind flange (on the wall of the tank).
- C. Temporary piping can be run over the natural ground and / or across the top of the FEB.
- D. The CONTRACTOR shall protect the existing above-ground small diameter non-potable water line near the FEB.

3.03 SLUDGE REMOVAL & CLEANING

- A. The OWNER shall be responsible for removing the contents of the FEB to approximately 8 feet sidewater depth. The CONTRACTOR shall be responsible for the removal of the remainder of the contents of the FEB (volume stated herein).
- B. Material inside the FEB consists of sludge, grit, screenings and debris. Contents shall be dewatered using mobile trailer mounted dewatering equipment (i.e. belt filter presses) provided by the CONTRACTOR. The dewatered material shall be disposed of at an approved landfill. Filtrate from the dewatering process to be collected (i.e surge tank) and be conveyed to an OWNER approved process drain, manhole or lift station. All temporary tanks, pumping and piping required to route filtrate to the drain shall be provided by the CONTRACTOR.
- C. The CONTRACTOR shall use caution when cleaning the FEB as there is piping, mixing equipment, and related supports that may interfere with the cleaning process and be vulnerable to damage. Manual removal of grit and debris will likely be required in areas near these items. The CONTRACTOR shall be solely responsible for any damage to existing piping and equipment and shall make repairs at no cost to the OWNER.
- D. The CONTRACTOR shall perform all sampling and analyses required for measurement of the sludge quantity and quality deposited into a landfill.
- E. Sludge sampling and testing to determine percent total solids content (percent TS) are to be completed by the CONTRACTOR following the established laboratory procedures specified in Test 2540G of the 19th Edition of "Standard Methods". The CONTRACTOR shall run this test once in the morning and once in the afternoon of each day sludge is removed from the site.
- F. Grit sampling and testing to determine Grit Size Characterization and Sand Equivalent Size are to be completed following the established laboratory procedures specified in Test 2540B and 2540E of the 19th Edition of "Standard Methods".
 - 1. A total of twelve (12) samples are to be collected, which will include four (4) samples around the FEB at three different depths.
 - 2. All samples are to be labeled with the date, time, and location of sampling.
 - 3. Contractor shall send samples to GRIT TECH laboratory, or approved equal, for analysis. Contractor shall coordinate with laboratory to provide all required containers, shipping materials, and postage for transport of grit samples.
- G. The volume of sludge hauled from the site for disposal shall be recorded on a per truckload basis by the CONTRACTOR. The CONTRACTOR shall maintain a log book in which the load quantity each vehicle removes each day is recorded. The CONTRACTOR shall furnish OWNER with dimensions of each vehicle used to haul sludge. The OWNER or the Owner's Representative may conduct a visual inspection of each truck as it is loaded. Any other means of determining the volume of residuals hauled from the site for disposal may be proposed by the CONTRACTOR but requires written approval by the OWNER.
 - 1. The dry tonnage of solids hauled from the site for disposal shall be calculated as the sum of the dry tonnage disposed over the Contract period. Daily dry tonnage

shall be calculated each day that sludge is hauled, based on the recorded volume of sludge hauled multiplied by the average solids content of per Paragraph 3.03.E above, in accordance with the following equation:

$$[TS \times VOL] \times C = \text{Dry tons applied}$$

Where:

TS = Average percent total solids as determined by the CONTRACTOR's laboratory analyses

VOL = Recorded volume of sludge removed (gallons)

C = 4.17×10^{-6} (unit conversion factor)

- H. After removal of materials from the FEB, the CONTRACTOR shall thoroughly pressure wash the interior to the satisfaction of the Owner's Representative employing industrial grade pressure washers with Cleaning Unit ratings of not less than 5,000 psi.

3.04 TRANSPORT AND DISPOSAL OF MATERIALS

- A. The CONTRACTOR shall be licensed to transport the dewatered material removed from the FEB to the disposal site or employ the services of a professional hauler that has the necessary licenses and permits.
- B. A Toxicity Characteristic Leaching Procedure (TCLP) shall be completed prior to hauling any dewatered contents from the plant at no additional cost to the OWNER.
- C. The CONTRACTOR shall transport dewatered sludge/contents removed from the FEB for disposal at a Type I landfill (unless the TCLP indicates a more stringent landfill is required).
- D. The CONTRACTOR shall take precautions to prevent spillage or liquid leakage from the hauling vehicle. The CONTRACTOR shall be responsible for any spills or leakage that occur as a result of the sludge hauling operations. Spilled sludge shall be removed immediately and cleanup work completed immediately. Cleanup of spilled sludge left unresolved for more than 4 hours may be performed or contracted by the OWNER on an emergency basis and the cost shall be withheld from the CONTRACTOR's final payment. This in no way shall relieve the CONTRACTOR of responsibility for the spill or subsequent results of the spill.

3.05 POWER SUPPLY

- A. The CONTRACTOR shall coordinate with Austin Energy to provide temporary power for any temporary pumping equipment at no additional cost to the OWNER.

3.06 MEASUREMENT AND PAYMENT

- A. Measurement and payment shall be in accordance with 01030 – Alternates.

END OF SECTION

SECTION 02060

PRESSURE WASHING FOR CLEANING (ALTERNATE)

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish all materials, labor, equipment (including aerial lift devices, scaffolding, and other height reducing equipment, if applicable), and supervision required to execute the services in accordance with this specification. Services shall include:
1. Collecting and removing trash and debris for proper disposal.
 2. Erecting safety signs, barricades, and cones when power-washing all interior and exterior areas.
 3. Vacuuming (use of blowers is prohibited) and pre-cleaning work area, and the removal of excess water that has pooled or is standing.
 4. Utilize only Occupational Safety and Health Administration (OSHA) and Leadership in Energy and Environment and Design (LEED) approved chemicals (see links below for acceptable products list).
 - a. Green Seal Certified Products, www.greenseal.org
 - b. EcoLogo Certified Products, www.ecologo.org
 5. The Contractor shall have the sole responsibility for adhering to and maintaining compliance with all applicable and most current revision of all local, State, and Federal laws, statutes, codes, and regulations. A claim of ignorance or lack of awareness of any such governmental requirements shall be rejected by the Owner. Following are some of the requirements Contractor must follow — this is not a comprehensive list of requirements, but is meant to assist the Contractor.
 - a. Wastewater disposal shall be in compliance with the most current revision of Austin Water Requirements.
 - b. Wastewater disposal manifest:
 - (i) The Contractor shall submit a copy of the wastewater disposal manifest to the Owner within five (5) business days of disposal of the water. The manifest shall include quantity of wastewater disposed and disposal location.

1.02 SAFETY

- A. Contractor shall adhere to all OSHA, state and local codes, rules and regulations concerning safety.
- B. Contractor shall be responsible for assuring the safety of its employees, Owner employees and the public during performance of all services under this contract.
- C. Contractor is responsible for reporting to the Owner any damage found prior to any work at job sites.
- D. All wastewater will be disposed of within strict City, State, and Federal guidelines.

- E. Contractor shall make sure that all applicable barriers and warning signs are in place before starting any work.

1.03 SUSTAINABILITY

- A. The Owner prefers Contractors to demonstrate innovative approaches to reducing their impact on the natural environment through use of alternative energy, low-emission equipment, biodegradable chemicals, or items with recycled content. During the term of this contract, when requested by the Owner, the Contractor will provide details of its organization's efforts to minimize the harmful effects upon the environment as well as any economic and equitable attributes. Specifically include any actions designed to:
 - 1. Conserve natural resources including water, energy, and raw materials throughout the product lifecycle;
 - 2. Minimize environmental impacts such as water and air pollution;
 - 3. Eliminate or reduce toxics that create hazards to workers, citizens, wildlife, and the environment;
 - 4. Support up-cycling and recycling efforts as well as utilize products with high recycled content;
 - 5. Reduce environmental impacts in your organization's production and distribution systems;
 - 6. Support worker health, safety, and fair wages;
 - 7. Consider total cost of ownership during the product's useful life, including operation, supplies, maintenance, and disposal cost.

PART 2 PRODUCTS

2.01 EQUIPMENT AND MATERIALS

- A. The Contractor shall furnish all equipment (including aerial lift devices, scaffolding, or height-reducing, if applicable) and materials. Equipment, materials, and/or supplies must meet or exceed the requirements of this Scope of Work for the services to be performed, and utilizing the safest possible equipment and techniques in order to minimize the risk of injury to persons and property.
- B. Any equipment, material, and/or supplies found to be defective, not meeting specifications, or which are in use without the written approval of the Owner shall, upon discovery (including any time within the period of the guarantee), shall be immediately replaced with equipment, material and/or supplies that meet specifications or are approved by the Owner at no additional cost to the city.

2.02 EQUIPMENT

- A. All equipment utilized by Contractor shall be maintained in good operating condition at all times and shall meet all local, state, and Federal requirements. All safety devices required by OSHA guidelines shall be in place and in proper operating condition.
 - 1. Title 6, Environmental Control and Conservation, paragraph 6-4-11 (B) of the City of Austin's Water Conservation Code provides that a person may not use commercially operated cosmetic power or pressure washing equipment unless it is

fitted with a water recycling unit, uses a spray nozzle using no more than 3.5 gallons of water per minute, and employs a working trigger shut-off with a protective weep mechanism.

- B. The City prefers the use of propane or electrical powered equipment, however, gasoline-powered equipment will be allowed. All gasoline-powered equipment (washers and generators) shall be California Air Resources Board (CARB) compliant. The Contractor shall submit proof of CARB compliance within 48-business hours of request by the City.
- C. All gasoline storage containers shall be OSHA-approved and not stored at the work-site or on City property at any time.
- D. Contractor shall not use gasoline-powered maintenance equipment on days declared as Ozone Action Days.
- E. Contractor shall provide and ensure that proper personal protection equipment shall be worn at all times by the operator of the equipment and any other employees of the contractor at the project site.
- F. Contractor shall provide, in writing, any updates or changes to the list of submitted power equipment, including make and model number, three (3) business days prior to use of the equipment at any location.

PART 3 EXECUTION

3.01 POWER WASHING SERVICES

- A. The work site shall be maintained in such a manner as to promote a neat appearance. The quality of the service shall be at the highest level achievable using the industry's most current power washing methods.
- B. The Contractor shall complete the work within one (1) working day.
 - 1. If during the performance of services, the Contractor determines that additional time is needed to complete the work, the Contractor and the Owner will mutually agree to a new date for completion of work. Under no circumstances shall the Contractor leave services unfinished without prior approval/arrangement.
- C. All work is subject to inspection and acceptance by the Owner.
- D. Upon completion of services, the Contractor shall be responsible for the immediate clean-up of the work area and removal of debris. The Contractor shall keep the work area, and other areas affected by the work free from accumulations of waste, rubbish, litter, or disorder. The Contractor shall at all times maintain the work area in a neat orderly manner. At the completion of work, Contractor shall immediately remove and properly dispose of all waste materials and debris from site.
- E. If power washing causes water or debris to be splashed on the interior or exterior of building surfaces/windows, the Contractor shall be responsible for the immediate cleaning of the soiled surface and returning it to its original state.

- F. The Contractor shall provide services using a method that prevents pollution of water resources.
- G. The Contractor's manner of work performance shall not damage any existing finishes, paint/coating, landscaping or other plant, property, or equipment. Prudent protection measures shall be taken at all times. When in doubt, Contractor shall contact the Owner prior to taking a particular action. The Contractor shall be held accountable for damage caused the Contractor or its Subcontractor(s) during the performance of work. The Contractor shall immediately inform the Owner of any damage and shall be fully responsible for the repair or replacement of damaged items, surfaces, or areas, at no expense to the Owner.

3.02 ACCEPTANCE OF WORK

- A. All work performed shall be in accordance with the specifications detailed herein.
- B. All work is subject to review and acceptance by the Owner.

3.03 OMISSIONS

- A. It is the intention of this Scope of Work to acquire complete power-washing services of the type described, with all necessary, applicable, components delivered, installed, and ready for full use. All items or services omitted from the Scope of Work which are clearly necessary for this service shall be considered a requirement although not directly specified or called for herein.

3.04 MEASUREMENT AND PAYMENT

- A. Measurement and payment shall be in accordance with 01030 – Alternates.

END OF SECTION

SECTION 02732
SELECTIVE DEMOLITION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Demolition and removal of selected portions of building or structure.
2. Acquiring permits and licenses and paying governmental fee and other charges necessary for proper execution of the work.
3. Abatement of Hazardous Materials (to be undertaken by the OWNER under separate contract).
4. Protection of existing utilities.
5. Protection of existing work indicated to remain.
6. Demolition of selective building elements as indicated.
7. Alteration of existing roofing, to permit installation of new equipment, materials and systems.
8. Removal and disposal of demolished materials.

B. Related Requirements:

1. Section 01010 "Summary of Work" for restrictions on use of the premises, Owner-occupancy requirements, and phasing requirements.
2. See Division 1 – General Requirements for the other sections related to the work described herein.

1.02 DEFINITIONS

- A. Remove: Detach items from existing construction and dispose of them off-site unless indicated to be salvaged or reinstalled.
- B. Remove and Salvage: Detach items from existing construction, in a manner to prevent damage, and deliver to Owner.
- C. Remove and Reinstall: Detach items from existing construction, in a manner to prevent damage, prepare for reuse, and reinstall where indicated.
- D. Existing to Remain: Leave existing items that are not to be removed and that are not otherwise indicated to be salvaged or reinstalled.

1.03 HAZARDOUS MATERIALS

- A. The presence of asbestos was found in the brown caulking at the window frames and vent louvers. The City of Austin will abate these locations prior to demolition under a separate contract. The presence of asbestos was not found in the red and black equipment gaskets or the CMU walls tested and can be safely removed by the contractor. If asbestos containing material is found during construction, the City of Austin will abate these locations as needed under a separate contract prior to demolition.

1.04 MATERIALS OWNERSHIP

- A. Unless otherwise indicated, demolition waste becomes property of Contractor.

1.05 PREINSTALLATION MEETINGS

- A. Predemolition Conference: Conduct conference at Project site.
 - 1. Inspect and discuss condition of construction to be selectively demolished.
 - 2. Review structural load limitations of existing structure.
 - 3. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
 - 4. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
 - 5. Review areas where existing construction is to remain and requires protection.

1.06 INFORMATIONAL SUBMITTALS

- A. Proposed Protection Measures: Submit report, including Drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, for dust control and, for noise control. Indicate proposed locations and construction of barriers.
- B. Schedule of Selective Demolition Activities: Indicate the following:
 - 1. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure Owner's building manager's and other tenants' on-site operations are uninterrupted.
 - 2. Interruption of utility services. Indicate how long utility services will be interrupted.
 - 3. Coordination for shutoff, capping, and continuation of utility services.
 - 4. Coordination of Owner's continuing occupancy of portions of existing building and of Owner's partial occupancy of completed Work.
- C. Warranties: Documentation indicating that existing warranties are still in effect after completion of selective demolition.

1.07 CLOSEOUT SUBMITTALS

- A. Inventory: Submit a list of items that have been removed and salvaged.
- B. Landfill Records: Indicate receipt and acceptance of hazardous wastes by a landfill licensed to accept hazardous wastes.

1.08 FIELD CONDITIONS

- A. Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted.
- B. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.

- C. Notify Architect of discrepancies between existing conditions and Drawings before proceeding with selective demolition.
 - D. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.
 - 1. Hazardous materials will be removed by Owner before start of the Work.
 - 2. If suspected hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. Hazardous materials will be removed by Owner under a separate contract.
 - E. Storage or sale of removed items or materials on-site is not permitted.
 - F. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.
 - 1. Maintain fire-protection facilities in service during selective demolition operations.
- 1.09 WARRANTY
- A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials and using approved contractors so as not to void existing warranties. Notify warrantor before proceeding.
- 1.10 COORDINATION
- A. Arrange selective demolition schedule so as not to interfere with Owner's operations.
- PART 2 PRODUCTS
- 2.01 PERFORMANCE REQUIREMENTS
- A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
 - B. Standards: Comply with ANSI/ASSP A10.6 and NFPA 241.
- PART 3 EXECUTION
- 3.01 EXAMINATION
- A. Verify that utilities have been disconnected and capped before starting selective demolition operations.
 - B. Review Project Record Documents of existing construction or other existing condition and hazardous material information provided by Owner. Owner does not guarantee that existing conditions are same as those indicated in Project Record Documents.
 - C. Verify that hazardous materials have been remediated before proceeding with building demolition operations.

- D. Survey of Existing Conditions: Correlate with requirements indicated to determine extent of selective demolition required.

3.02 UTILITY SERVICES AND MECHANICAL/ELECTRICAL SYSTEMS

- A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.
- B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off utility services and mechanical/electrical systems serving areas to be selectively demolished.
 - 1. Owner will arrange to shut off indicated services/systems when requested by Contractor.
 - 2. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
 - 3. Disconnect, demolish, and remove fire-suppression systems, plumbing, and HVAC systems, equipment, and components indicated on Drawings to be removed.
 - a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material and leave in place.
 - c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
 - f. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
 - g. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material and leave in place.

3.03 PROTECTION

- A. Temporary Protection: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
 - 1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
 - 2. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.
 - 3. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.
 - 4. Cover and protect furniture, furnishings, and equipment that have not been removed.

5. Comply with requirements for temporary enclosures, dust control, heating, and cooling.
- B. Temporary Shoring: Design, provide, and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.
 1. Strengthen or add new supports when required during progress of selective demolition.
 - C. Remove temporary barricades and protections where hazards no longer exist.
- 3.04 SELECTIVE DEMOLITION, GENERAL
- A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:
 1. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.
 2. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping. Temporarily cover openings to remain.
 3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
 4. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain portable fire-suppression devices during flame-cutting operations.
 5. Dispose of demolished items and materials promptly. Comply with requirements in Division 01 Section Construction and Demolition Waste Management.
 - B. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
 - C. Removed and Salvaged Items:
 1. Clean salvaged items.
 2. Pack or crate items after cleaning. Identify contents of containers.
 3. Store items in a secure area until delivery to Owner.
 4. Protect items from damage during transport and storage.
 - D. Removed and Reinstalled Items:
 1. Clean and repair items to functional condition adequate for intended reuse.
 2. Pack or crate items after cleaning and repairing. Identify contents of containers.
 3. Protect items from damage during transport and storage.

4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.

E. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Architect, items may be removed to a suitable, protected storage location during selective demolition and cleaned and reinstalled in their original locations after selective demolition operations are complete.

3.05 CLEANING

A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

3.06 MEASUREMENT AND PAYMENT

A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 03600

GROUT

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Provide all labor, materials, equipment, and incidentals as shown, specified and required to furnish and install grout.

1.02 RELATED WORK

- A. Coordinate the requirements of this section with all other sections of the Specifications.

1.03 REFERENCE STANDARDS

- A. American Concrete Institute (ACI)
 - 1. ACI 211.1, Practice for Selecting Proportions for Normal, Heavy-Weight and Mass Concrete.
 - 2. ACI 301, Specification for Structural Concrete.
- B. American Society for Testing and Materials (ASTM).
 - 1. ASTM C33, Specification for Concrete Aggregates.
 - 2. ASTM C109, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars.
 - 3. ASTM C150, Specification for Portland Cement.
 - 4. ASTM C230, Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
 - 5. ASTM C531, Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical- Resistant Mortars, Grouts, Monolithic Surfacing and Polymer Concrete.
 - 6. ASTM C579, Standard Test Method for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacing and Polymer Concretes.
 - 7. ASTM C827, Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures.
 - 8. ASTM C882, Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
 - 9. ASTM C937, Specification for Grout Fluidifier for Preplaced-Aggregate Concrete.
 - 10. ASTM C939, Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
 - 11. ASTM C1107, Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
 - 12. ASTM C1181, Standard Test Method for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.

1.04 SUBMITTALS

- A. Grout Mix Design:

1. For Grout Fill and Construction Joint Grout, submit the following:
 - a. grout mix design
 - b. laboratory test reports for grout strength tests.
 - B. Reports and Certificates, submit the following:
 1. For proprietary materials, submit copies of Manufacturer's certification of compliance with the specified properties for Class I, II, and III grouts.
 2. Certified testing lab reports for tests specified herein for nonproprietary materials.
 3. Certifications that all grouts used on the project are free of chlorides or other chemicals causing corrosion.
 4. Manufacturer's specifications and installation instructions for all proprietary materials.
- 1.05 PRODUCT DELIVERY, STORAGE AND HANDLING
- A. Delivery of Materials: Grout materials from Manufacturers shall be delivered in unopened containers and shall bear intact Manufacturer's labels.
 - B. Storage of Materials: Grout materials shall be stored in a dry shelter and shall be protected from moisture.
- 1.06 QUALITY ASSURANCE
- A. Installer Qualifications: An experienced installer who has completed grout work of similar scope and complexity with similar materials as found on this Project.
 - B. Testing Agency Qualifications: An experienced independent testing agency, acceptable to authorities having jurisdiction and the ENGINEER that is qualified according to applicable ASTM standards to conduct the testing indicated.
 - C. Field Tests:
 1. Compression test specimens shall be taken during construction from the first placement of each type of grout, and at intervals thereafter as selected by the ENGINEER to ensure continued compliance with these specifications. The specimens will be made by the ENGINEER or its representative.
 2. Compression tests and fabrication of specimens for non-shrink grout shall be performed as specified in ASTM C109. A set of three specimens will be made for testing at seven days, 28 days, and each additional time period as appropriate.
 3. Compression tests and fabrication of specimens for epoxy grout shall be performed as specified in ASTM C579, Method B. A set of three specimens will be made for testing at seven days, and each earlier time period as appropriate.
 4. The cost of all laboratory tests on grout will be borne by the OWNER, but CONTRACTOR shall assist in obtaining specimens for testing. However, CONTRACTOR shall be charged for the cost of any additional tests and investigation on work performed which does not conform to the requirements of the specifications. CONTRACTOR shall supply all materials necessary for fabricating the test specimens.

PART 2 PRODUCTS

2.01 GROUTS

- A. General: Non-shrink grout shall be a prepackaged, inorganic, flowable, non-gas-liberating, non-metallic, cement-based grout requiring only the addition of water. Manufacturer's instructions shall be printed on each bag or other container in which the materials are packaged. The specific formulation for each class of non-shrink grout specified herein shall be that recommended by the Manufacturer for the particular application.
- B. Class 1 Non-Shrink Grout:
 - 1. Required minimum 28 day compressive strength is 7000 psi.
 - 2. Shall meet the requirements of ASTM C1107 and the minimum compressive strength requirements when tested using the amount of water required to achieve the following properties:
 - a. Flowable consistency (125 to 145 percent flow on ASTM C230, five drops in 3 seconds).
 - 3. The grout shall not bleed when tested at maximum allowed water.
 - 4. The non-shrink property is not based on a chemically generated gas or gypsum expansion.
 - 5. Product and Manufacturer: Provide one of the following (or approved equivalent):
 - a. Master Flow 100, as manufactured by BASF Building Systems.
 - b. Five Star Grout, as manufactured by Five Star Products.
- C. Class 2 Non-Shrink Grout:
 - 1. Required minimum 28 day compressive strength is 7000 psi.
 - 2. Shall meet the requirements of ASTM C1107 Grades B and C and minimum compressive strength requirements when tested using the amount of water required to achieve the following properties:
 - a. Fluid consistency (20 to 30 seconds in accordance with ASTM C 939).
 - 3. The length change from placement to time of final set shall not have a shrinkage greater than the amount of expansion measured at 3 or 14 days. The expansion at 3 or 14 days shall not exceed the 28-day expansion.
 - 4. The non-shrink property is not based on a chemically generated gas or gypsum expansion.
 - 5. Product and Manufacturer: Provide one of the following (or approved equivalent):
 - a. Masterflow 928, as manufactured by BASF Building Systems.
 - b. Five Star Fluid Grout 100, as manufactured by Five Star Products, Inc.
- D. Class 3 Non-Shrink Epoxy Grout:
 - 1. Epoxy grout shall be a pourable, non-shrink, 100 percent solids system. The epoxy grout system shall have three components: resin, hardener, and specially blended aggregate, all premeasured and prepackaged. The resin component shall not contain any non-reactive diluents. Resins containing butyl glycidyl ether (BGE) or other highly volatile and hazardous reactive diluents are not acceptable. Variation of component ratios is not permitted, unless specifically recommended by the

Manufacturer. Manufacturer's instructions shall be printed on each container in which the materials are packaged.

2. Required minimum 7 day compressive strength is 13,000 psi when tested in accordance with ASTM C579.
3. The following properties shall be attained with the minimum quantity of aggregate allowed by the Manufacturer.
 - a. The vertical volume change at all times before hardening shall be between 0.0 percent shrinkage and four percent expansion when measured according to ASTM C827 (modified for epoxy grouts by using an indicator ball with a specific gravity between 0.9 and 1.1). Alternately, epoxy grouts which maintain an effective bearing area of not less than 95 percent are acceptable.
 - b. The length change after hardening shall be negligible (less than 0.0006 in/in) and the coefficient of thermal expansion shall be less than 0.00003 in/in/F when tested in accordance to the requirements of ASTM C531.
 - c. The compressive creep at one year shall be negligible (less than .001 in/in) when tested under a 400 psi constant load at 140°F in accordance to the requirements of ASTM C1181.
 - d. The grout shall be capable of maintaining at least a flowable consistency for a minimum of 30 minutes at 70°F.
 - e. The shear bond strength to Portland cement concrete shall be greater than the shear strength of the concrete when tested in accordance to the requirements of ASTM C882.
 - f. The effective bearing area shall be a minimum of 95 percent.
4. Product and Manufacturer: Provide one of the following:
 - a. Sikadur 42 Grout Pak, as manufactured by Sika Corporation.
 - b. DP Five Star Epoxy Grout, as manufactured by Five Star Products.

E. Grout Fill & Topping Grout:

1. Grout for topping of slabs and concrete fill for built-up surfaces of tank, channel, and basin bottoms shall be composed of cement, fine aggregate, coarse aggregate, water, and admixtures proportioned and mixed as specified herein. All materials and procedures specified for normal concrete in Section 03300 shall apply except as noted otherwise herein.
2. Topping grout and concrete fill shall contain a minimum of 517 pounds of cement per cubic yard (5.5 sacks) with a maximum water cement ratio of 0.45.
3. Minimum 28 day compressive strength shall be 4000 psi.
4. Coarse aggregate shall be No. 8 (3/8" max) per Section 03300.
5. Fine aggregate shall be as required in Section 03300.
6. Slump shall be adjusted to match placement and finishing conditions, but shall not exceed 4 inches.
7. Final mix design shall be as determined by trial mix design under supervision of the approved testing laboratory.
8. Where grout placement is thicker than 4 inches, use Class S concrete as specified in Section 403S.

F. Requirements for Grout Fill and Topping Grout

1. Proportion mixes by either laboratory trial batch or field experience methods, using materials to be employed on the Project for grout required. Comply with ACI 211.1 and report to ENGINEER the following data:
 - a. Complete identification of aggregate source of supply.
 - b. Tests of aggregates for compliance with specified requirements.
 - c. Scale weight of each aggregate.
 - d. Absorbed water in each aggregate.
 - e. Brand, type and composition of cement.
 - f. Brand, type and amount of each admixture.
 - g. Amounts of water used in trial mixes.
 - h. Proportions of each material per cubic yard.
 - i. Gross weight and yield per cubic yard of trial mixtures.
 - j. Measured slump.
 - k. Measured air content.
 - l. Compressive strength developed at seven days and 28 days, from not less than three test specimens cast for each seven day and 28 day test, and for each design mix.
 2. Laboratory Trial Batches: When laboratory trial batches are used to select grout proportions, prepare test specimens and conduct strength tests as specified in ACI 301, Section 4.
 3. Field Experience Method: When field experience methods are used to select grout proportions, establish proportions as specified in ACI 301, Section 4.
 4. Admixtures: Use air-entraining admixture in all grout. Use amounts of admixtures as recommended by the Manufacturer for climatic conditions prevailing at the time of placing. Adjust quantities and types of admixtures as required to maintain quality control. Do not use admixtures which have not been incorporated and tested in the accepted design mix, unless otherwise authorized in writing by ENGINEER.
- G. Grout Applications: The following is a listing of typical applications and the corresponding type of grout which is to be used. Unless indicated otherwise in the Drawings, grouts shall be provided as listed below.

<i>Application</i>	<i>Grout Type</i>
Beam Base Plates	Class 1
Column Base Plates	Class 2
Equipment & Tank Base Plates	Class 2
Machinery Base Plates	Class 3
Filling blockout spaces for embedded items (railing posts, gate guide frames, etc.)	Class 2
Toppings & fill 4 inches or less	Grout Fill & Topping Grout

Toppings & fill greater than 4 inches	Class S Concrete (Section 403S)
All other applications	Class 1

2.02 CURING MATERIALS

- A. Curing materials shall be as specified in Section 410S and as recommended by the Manufacturer of prepackaged grouts.

2.03 CONSISTENCY

- A. The consistency of grouts shall be that necessary to completely fill the space to be grouted for the particular application.

PART 3 EXECUTION

3.01 INSPECTION

- A. CONTRACTOR shall examine the substrate and conditions under which grout is to be placed and notify ENGINEER, in writing, of unsatisfactory conditions. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to ENGINEER.

3.02 INSTALLATION

- A. General:
 1. Place grout as shown on the Drawings and in accordance with Manufacturer's instructions. If Manufacturer's instructions conflict with the Specifications do not proceed until ENGINEER provides clarification.
 2. Manufacturers of proprietary products shall make available upon 72 hours notification the services of a qualified, full time employee to aid in assuring proper use of the product under job conditions.
 3. Placing grout shall conform to temperature and weather limitations in Sections 403S and 410S.
 4. Grout shall be cured following Manufacturer's instructions for prepackaged grout and the requirements in Section 403S and 410S.
- B. Columns, Beams and Equipment Bases:
 1. After shimming base plate to proper grade, securely tighten anchor bolts. Properly form around the base plates, allowing sufficient room around the edges for placing the grout. Adequate depth between the bottom of the base plate and the top of concrete base must be provided to assure that the void is completely filled with the grout.
- C. Handrails and Railings:
 1. After posts have been properly inserted into the holes or sleeves, fill the annular space between posts and sleeve with the grout. Bevel grout at juncture with post so that moisture flows away from post.

D. Topping Grout:

1. All mechanical, electrical, and finish work shall be completed prior to placement of topping grout. The base slab shall be given a roughened textured surface by sandblasting or hydro-blasting exposing the aggregates to ensure bonding to the base slab.
2. Apply topping grout as shown in the Drawings; the minimum thickness of grout topping shall be 1-inch.
3. The base slab shall be thoroughly cleaned and wetted prior to placing topping and fill. No topping shall be placed until the slab is complete free from standing water. A thin coat of neat Type II cement slurry shall be broomed into the surface of the slab and topping shall be placed while the slurry is still wet. The topping shall be compacted by rolling or tamping, brought to established grade, and floated. Grouted fill for tank and basin bottoms where scraping mechanisms are to be installed shall be screeded by blades attached to the revolving mechanism of the equipment in accordance with the procedures outlined by the equipment Manufacturer after the grout is brought to the established grade.
4. Topping grout placed on sloping slabs shall proceed uniformly from the bottom of the slab to the top, for the full width of the placement.
5. The surface shall be tested with a straight edge to detect high and low spots which shall be immediately eliminated. When the topping has hardened sufficiently, it shall be steel troweled to a smooth surface free from pinholes and other imperfections. An approved type of mechanical trowel may be used as an assist in this operation, but the last pass over the surface shall be by hand-troweling. During finishing, no water, dry cement or mixture of dry cement and sand shall be applied to the surface.
6. Cure and protect the grout topping as specified in Section 410S.

E. Grout Fill

1. All mechanical, electrical, and finish work shall be completed prior to placement of grout fill. Grout fill shall be mixed, placed, and finished as required in Section 410S.
2. The minimum thickness of grout fill shall be 1 inch. Where the finished surface of grout fill is to form an intersecting angle of less than 45 degrees with the concrete surface it is to be placed against, a key shall be formed in the concrete surface at the intersection point. The key shall be a minimum of 3 1/2 inches wide by 1 1/2 inches deep.
3. The surface shall be tested with a straight edge to verify that the surface slopes uniformly to drain and to detect high and low spots which shall be immediately eliminated. When the grout fill has hardened sufficiently, it shall be steel troweled to a smooth surface free from pinholes and other imperfections. During finishing, no water, dry cement or mixture of dry cement and sand shall be applied to the surface.

3.03 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials,

labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 03740

CONCRETE REPAIR AND MODIFICATIONS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required to cut, remove, repair or otherwise modify parts of in-place concrete.
- B. Work under this Section may also be performed as a remedy for improperly or poorly placed concrete, or concrete damaged during construction operations. Such work shall be performed only after receiving written directions from the ENGINEER.

1.02 REFERENCE STANDARDS

- A. American Society for Testing and Materials (ASTM).
 - 1. ASTM C78 – Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
 - 2. ASTM C109 – Standard Test Method for Compressive Strength of Hydraulic Cement Mortars.
 - 3. ASTM C293 – Standard Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading).
 - 4. ASTM C321 – Standard Test Method for Bond Strength of Chemical-Resistant Mortars.
 - 5. ASTM C348 – Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
 - 6. ASTM C496 – Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
 - 7. ASTM C881 – Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
 - 8. ASTM C882 – Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.
 - 9. ASTM D638 – Standard Test Method for Tensile Properties of Plastics.
 - 10. ASTM D695 – Standard Test Method for Compressive Properties of Rigid Plastics.
 - 11. ASTM D790 – Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

1.03 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of the General Conditions and Division 1, General Requirements.
- B. Submit a Schedule of Demolition which includes the detailed methods of demolition to be used at each location.
- C. Submit a Plan of Repair for any structure that requires repair which includes the detailed methods of repair to be utilized.

- D. Submit Manufacturer's technical literature on all product brands proposed for use. The submittal shall include the Manufacturer's installation and/or application instructions.
- E. When substitutions for acceptable brands of materials specified herein are proposed by the CONTRACTOR, submit Manufacturer's substitutions for approval prior to delivery to the Site. Submitted data shall demonstrate compliance with all requirements of this Specification or deviations shall be clearly noted.

1.04 QUALITY ASSURANCE

- A. No existing structure or concrete shall be shifted, cut, removed, or otherwise altered until authorization is given by the ENGINEER.
- B. No proposed or existing structure shall be repaired or otherwise altered until authorization is given by the ENGINEER. Notify the ENGINEER of any defects in the original construction and submit a proposed repair plan for review.
- C. When removing materials or portions of existing structures and when making openings in existing structures, all precautions shall be taken and all necessary barriers, shoring and bracing, and other protective devices shall be erected to prevent damage to the structures beyond the limits necessary for the new work to protect personnel, to control dust, and to prevent damage to the structures or contents by falling or flying debris.
- D. Manufacturer qualifications. The Manufacturer of the specified products shall have a minimum of 5 years experience in the manufacture of such products, and shall have an ongoing program to provide training and technical support for the CONTRACTOR's personnel.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver the specified products in original, unopened containers with the Manufacturer's name, labels, product identification, and batch numbers.
- B. Store products as recommended by the Manufacturer.

PART 2 PRODUCTS

2.01 GENERAL

- A. Materials shall comply with these Specifications and any applicable federal, state or local regulations.
- B. All materials used shall be approved for use in potable water facilities.

2.02 REPAIR CONCRETE

- A. Use Class S concrete in accordance with Section 403S for large volume repairs unless otherwise directed.

2.03 REPAIR MORTAR

- A. Repair mortar shall be a polymer modified prepackaged cementitious repair mortar.
- B. Use an appropriate product for the specific application in accordance with all Manufacturer's requirements and recommendations.
- C. Material Properties.
 - 1. Compressive strength (ASTM C109):
 - a. 3800 psi min. at 7 days.
 - b. 4800 psi min. at 28 days.
 - 2. Splitting Tensile strength (ASTM C496):
 - a. 500 psi min. at 28 days.
 - 3. Flexural strength (ASTM C78):
 - a. 1300 psi min. at 28 days.
 - 4. Bond strength (ASTM C882 Modified):
 - a. 2000 psi min. at 28 days.
 - 5. Color to match surrounding material color which is exposed to view.
- D. Acceptable Products and Manufacturers (or approved equivalent):
 - 1. SikaTop 121 Plus as manufactured by Sika Corporation.
 - 2. SikaTop 122 Plus as manufactured by Sika Corporation.
 - 3. SikaTop 123 Plus as manufactured by Sika Corporation.
 - 4. EMACO R310 CI, as manufactured by BASF.

2.04 STRUCTURAL CRACK INJECTION

- A. Concrete Sealing Epoxy
 - 1. High strength moisture insensitive epoxy system in compliance with ASTM C881, Type IV, Grade 3, Class B & C and with the following properties:
 - a. Tensile properties at 14 days (ASTM D638)
 - (i) Tensile strength: 5,500 psi
 - (ii) Minimum elongation: 2%
 - b. Compressive properties at 28 days (ASTM D695)
 - (i) Compressive strength: 10,000 psi
 - (ii) Modulus of elasticity: 300,000 psi
 - c. Flexural strength: 12,000 psi at 14 days (ASTM D790)
 - d. Compressive strength: 14,000 psi (ASTM D695)
 - e. Bond strength: 2,200 psi after 2 days (ASTM C882)
 - f. Maximum water absorption of 0.1 percent after 24 hours
 - 2. The color of the sealing epoxy shall match the existing color of surrounding concrete surfaces if exposed to view.

- B. Epoxy Injection Resin
 - 1. High modulus, low viscosity epoxy crack injection system in compliance with ASTM C881, Type IV, Grade 1, Class B&C and with the following properties:
 - a. Tensile properties at 14 days (ASTM D638)
 - (i) Tensile strength: 5,500 psi
 - (ii) Minimum elongation: 2%
 - b. Compressive properties at 28 days (ASTM D695)
 - (i) Compressive strength: 10,000 psi
 - (ii) Modulus of elasticity: 300,000 psi
 - c. Flexural strength: 12,000 psi (ASTM D790)
 - d. Bond strength: 2,800 psi after 2 days (ASTM C882)
 - e. Maximum water absorption of 0.15 percent after 24 hours

2.05 WATERPROOFING INJECTION

- A. Concrete Expansion Joint and Active Crack Sealing
 - 1. SikaFix HH Hydrophilic as manufactured by Sika Corporation, or approved equal.
- B. Water Infiltration Under Pressure
 - 1. SikaFix HH+ as manufactured by Sika Corporation, or approved equal.

2.06 WATER PRESSURE LEAKAGE AND SEEPAGE WATERSTOP

- A. Fast Setting Portland Cement Based Waterstop
 - 1. Material Properties
 - a. Compressive Strength (ASTM C109):
 - (i) 4200 psi min. at 7 days.
 - (ii) 6800 psi min. at 28 days.
 - b. Tensile Strength (ASTM C496):
 - (i) 600 psi min. at 7 days.
 - (ii) 700 psi min. at 28 days.
 - c. Setting Time (ASTM C266)
 - (i) Initial set of approximately 90 seconds.
 - d. Color
 - (i) Concrete gray.
 - 2. Acceptable Products and Manufacturers
 - a. SikaSet Plug as manufactured by Sika Corporation or approved equivalent.

PART 3 EXECUTION

3.01 GENERAL

- A. Finishes, joints, reinforcements, sealants, etc., shall be as specified in their respective Sections of the Specifications.

- B. All commercial products specified in this Section shall be mixed and applied in strict compliance with the Manufacturer's recommendations.
- C. In all cases where concrete is repaired in the vicinity of an expansion joint or isolation joint, the repairs shall be made to preserve the isolation between components on either side of the joint.
- D. When drilling holes in concrete for dowels or bolts, drilling shall stop if reinforcing steel is encountered. The hole shall be relocated to avoid reinforcing and the existing hole patched with repair mortar per this Section. Reinforcing shall not be cut. Where possible, reinforcing locations shall be identified prior to drilling using non-destructive methods such as "rebar locators", GPR, etc. so that drilled hole locations may be adjusted to avoid reinforcing interference prior to drilling.

3.02 CONCRETE REMOVAL

- A. General
 - 1. Concrete specified to be left in place which is damaged by the CONTRACTOR shall be repaired by approved means to the satisfaction of the ENGINEER at no cost.
- B. Concrete Removal Equipment
 - 1. Use sawing equipment capable of sawing concrete to the specified depth.
 - 2. Use power driven chipping tools no heavier than a 30 lb. class for bulk concrete removal and no heavier than a 15 lb. class for removal of concrete beneath reinforcing steel or along the edges of the repair area.
 - 3. Hydrodemolition equipment may be used with prior written approval of the ENGINEER or via an approved Schedule of Demolition.
- C. Concrete Removal Procedures and Requirements
 - 1. Concrete removal shall be initiated by first saw cutting to a depth of 1 inch (or by line drilling if saw cutting is not feasible) at the given removal limits. Remove concrete to the required depth by chipping or jack-hammering, as appropriate, in areas where concrete is to be taken out. Use the smallest equipment possible to avoid bruising or damaging concrete outside the removal zone and in accordance with this Section. Remove concrete in such a manner that surrounding concrete, existing reinforcing to be left in place and existing in place equipment are not damaged.
 - 2. All existing reinforcing exposed during concrete removal that will be covered with new material shall be undercut, exposing the entire perimeter of the bar, a minimum of 1 inch or 1.5 times the maximum aggregate size of the repair material, whichever is greater. Reinforcing to be left in place shall not be damaged during demolition.
 - 3. Where existing reinforcing is exposed due to saw cutting or core drilling and no new material is to be placed on the cut surface, a coating or surface treatment of epoxy paste shall be applied to the entire cut surface to a thickness of 1/4 inch. Reinforcing shall be drilled and ground to establish minimum cover requirements prior to application of the surface treatment.

3.03 REPAIR PREPARATION

A. Surface Preparation

1. Where bonding to existing surfaces, clean and remove all deteriorated materials, dirt, oil, grease, and all other bond inhibiting materials from the surface by abrasive blasting, grinding, etc. as approved by the ENGINEER. Irregular voids or surface stones need not be removed if they are sound, free of laitance, and firmly embedded into parent concrete.
2. Where bonding new concrete to existing concrete, the existing surface shall be roughened to a minimum 1/4 inch amplitude or greater if a larger amplitude is required by the repair material Manufacturer.

B. Existing Reinforcing Steel

1. Existing reinforcing which is exposed shall be cleaned by mechanical means to remove all loose material and corrosion products before proceeding with the repair.

3.04 REPAIR EXECUTION

A. Install any required formwork in accordance with Section 410S.

B. Prior to installing the repair concrete, or mortar, clean the concrete surface and apply mortar or epoxy bonding agents as required for Construction Joints in accordance with Section 410S Construction Joints. Apply a hydrophilic waterstop per Section 416S for water retaining structures or if called for in Drawings.

C. Install repair concrete, mortar or other repair material in accordance with all Manufacturer's instructions and Section 410S. In the event of a conflict between the Manufacturer's instructions and Section 410S, the more restrictive requirement shall apply.

D. Cure the repair in accordance with all Manufacturer's instructions and Section 410S. In the event of a conflict between the Manufacturer's instructions and Section 410S, the more restrictive requirement shall apply.

3.05 EPOXY CRACK INJECTION

A. Flush out cracks and voids with chemical agent or chemical solvent to remove dirt and laitance prior to epoxy injection.

B. Provide temporary entry ports spaced to accomplish movement of fluids between ports, complying with Manufacturer's recommendations. Provide seal at concrete surface to prevent epoxy leakage.

C. Inject epoxy into prepared ports under appropriate pressure, using equipment appropriate for the particular application. Begin injection at lower entry port and continue until adhesive appears at adjacent entry port; continue from port to port until each crack is filled.

D. After epoxy adhesive has set, remove temporary seal and excess adhesive. Grind surfaces smooth.

3.06 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 04200

UNIT MASONRY

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Concrete masonry units.
 - 2. Lintels.
 - 3. Mortar and grout materials.
 - 4. Reinforcement.
 - 5. Ties and anchors.
 - 6. Embedded flashing.
 - 7. Accessories.
 - 8. Mortar and grout mixes.
 - 9. Miscellaneous masonry accessories
- B. Products Installed but not Furnished under This Section:
 - 1. Steel lintels in unit masonry.
 - 2. Steel shelf angles for supporting unit masonry.

1.02 DEFINITIONS

- A. CMU(s): Concrete masonry unit(s).
- B. Reinforced Masonry: Masonry containing reinforcing steel in grouted cells.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For the following:
 - 1. Masonry Units: Indicate sizes, profiles, coursing, and locations of special shapes.
 - 2. Reinforcing Steel: Indicate bending, lap lengths, and placement of unit masonry reinforcing bars. Comply with ACI 315R. Indicate elevations of reinforced walls.
 - 3. Fabricated Flashing: Detail corner units, end-dam units, and other special applications.
- C. Samples for Initial Selection:
 - 1. Colored mortar.
- D. Samples for Verification: For each type and color of the following:
 - 1. Mortar samples using same sand and mortar ingredients to be used on Project, complying with ASTM C 270.
 - 2. Weep/cavity vents.

3. Cavity drainage material.
4. Accessories embedded in masonry.
5. Grout mixes complying with the compressive strength requirements of ASTM C 476. Include description of type and proportions of grout ingredients.

1.04 INFORMATIONAL SUBMITTALS

- A. List of Materials Used in Constructing Mockups: List generic product names together with manufacturers, manufacturers' product names, model numbers, lot numbers, batch numbers, source of supply, and other information as required to identify materials used. Include mix proportions for mortar and grout and source of aggregates.
 1. Submittal is for information only. Receipt of list does not constitute approval of deviations from the Contract Documents unless such deviations are specifically brought to the attention of Architect and approved in writing.
- B. Material Certificates: For each type of the following:
 1. Masonry units.
 - a. Include data on material properties material test reports substantiating compliance with requirements.
 - b. For masonry units, include data and calculations establishing average net-area compressive strength of units.
 2. Integral water repellent used in CMUs.
 3. Cementitious materials. Include name of manufacturer, brand name, and type.
 4. Mortar admixtures.
 5. Preblended, dry mortar mixes. Include description of type and proportions of ingredients.
 6. Grout mixes. Include description of type and proportions of ingredients.
 7. Reinforcing bars.
 8. Joint reinforcement.
 9. Anchors, ties, and metal accessories.
- C. Mix Designs: For each type of mortar and grout. Include description of type and proportions of ingredients.
 1. Include test reports for mortar mixes required to comply with property specification. Test in accordance with ASTM C109/C109M for compressive strength, ASTM C1506 for water retention, and ASTM C91/C91M for air content.
 2. Include test reports, in accordance with ASTM C1019, for grout mixes required to comply with compressive strength requirement.
- D. Statement of Compressive Strength of Masonry: For each combination of masonry unit type and mortar type, provide statement of average net-area compressive strength of masonry units, mortar type, and resulting net-area compressive strength of masonry determined in accordance with TMS 602.
- E. Cold-Weather and Hot-Weather Procedures: Detailed description of methods, materials, and equipment to be used to comply with requirements.

- F. Wall Mockups: Build mockups to verify selections made under Sample submittals to demonstrate aesthetic effects to set quality standards for materials and execution and to set quality standards for installation.
1. Build mockups for typical exterior and interior walls in sizes approximately 48 inches long by 48 inches high by full thickness, including face and backup wythes and accessories.
 - a. Include through-wall flashing installed for a 24-inch length in corner of exterior wall mockup approximately 16 inches down from top of mockup, with a 12-inch length of flashing left exposed to view (omit masonry above half of flashing).
 2. Where masonry is to match existing, erect mockups adjacent and parallel to existing surface.
 3. Protect accepted mockups from the elements with weather-resistant membrane.
 4. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations by Change Order.
 5. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Store masonry units on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied. If units become wet, do not install until they are dry.
1. Protect Type I concrete masonry units from moisture absorption so that, at the time of installation, the moisture content is not more than the maximum allowed at the time of delivery.
- B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.
- D. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

1.06 FIELD CONDITIONS

- A. Protection of Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.
1. Extend cover a minimum of 24 inches down both sides of walls, and hold cover securely in place.
 2. Where one wythe of multiwythe masonry walls is completed in advance of other wythes, secure cover a minimum of 24 inches down face next to unconstructed wythe, and hold cover in place.

- B. Stain Prevention: Prevent grout, mortar, and soil from staining the face of masonry to be left exposed or painted. Immediately remove grout, mortar, and soil that come in contact with such masonry.
 - 1. Protect base of walls from rain-splashed mud and from mortar splatter by spreading coverings on ground and over wall surface.
 - 2. Protect sills, ledges, and projections from mortar droppings.
 - 3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes, from mortar droppings.
 - 4. Turn scaffold boards near the wall on edge at the end of each day to prevent rain from splashing mortar and dirt onto completed masonry.
- C. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace unit masonry damaged by frost or by freezing conditions. Comply with cold-weather construction requirements contained in TMS 602.
 - 1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is 40 deg F and higher and will remain so until masonry has dried, but not less than seven days after completing cleaning.
- D. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602.

PART 2 PRODUCTS

2.01 SOURCE LIMITATIONS

- A. Obtain exposed masonry units, cementitious mortar components from single producer or manufacturer.

2.02 CONCRETE MASONRY UNITS

- A. Shapes: Provide shapes indicated and as follows, with exposed surfaces matching exposed faces of adjacent units unless otherwise indicated.
 - 1. Provide special shapes for lintels, corners, jambs, sashes, movement joints, headers, bonding, and other special conditions.
 - 2. Provide square-edged units for outside corners unless otherwise indicated.
- B. Integral Water Repellent: Provide units made with integral water repellent.
 - 1. Integral Water Repellent: Liquid polymeric, integral water-repellent admixture that does not reduce flexural bond strength. Units made with integral water repellent, when tested in accordance with ASTM E514/E514M as a wall assembly made with mortar containing integral water-repellent manufacturer's mortar additive, with test period extended to 24 hours, will show no visible water or leaks on the back of test specimen.
- C. CMUs: ASTM C90, normal weight.
 - 1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 1900 psi (13.1 MPa).

2. Size (Width): Manufactured to dimensions 3/8 inch less than nominal dimensions.
3. Provide Type I, moisture-controlled units.
4. Exposed Faces: Provide color and texture as selected from the Manufacturer's full range of standard integral colors.

2.03 LINTELS

- A. Masonry Lintels: Prefabricated or built-in-place masonry lintels made from bond beam CMUs matching adjacent CMUs in color, texture, and density classification, with reinforcing bars placed as indicated and filled with coarse grout. Cure precast lintels before handling and installing. Temporarily support built-in-place lintels until cured.

2.04 MORTAR MATERIALS

- A. Portland Cement: ASTM C150/C150M, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.
 1. Alkali content will not be more than 0.1 percent when tested in accordance with ASTM C114.
- B. Hydrated Lime: ASTM C207, Type S.
- C. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime containing no other ingredients. Complying with ASTM C 150, Type I or Type III, and hydrated lime complying with ASTM C 207.
- D. Do not use Masonry Cement or Mortar Cement.
- E. Mortar Pigments: Natural and synthetic iron oxides and chromium oxides, compounded for use in mortar mixes and complying with ASTM C979/C979M. Use only pigments with a record of satisfactory performance in masonry mortar.
- F. Aggregate for Mortar: ASTM C144.
 1. For mortar that is exposed to view, use washed aggregate consisting of natural sand or crushed stone.
 2. For joints less than 1/4 inch thick, use aggregate graded with 100 percent passing the No. 16 sieve.
 3. White-Mortar Aggregates: Natural white sand or crushed white stone.
 4. Colored-Mortar Aggregates: Natural sand or crushed stone of color necessary to produce required mortar color.
- G. Cold-Weather Admixture: Nonchloride, noncorrosive, accelerating admixture complying with ASTM C494/C494M, Type C, and recommended by manufacturer for use in masonry mortar of composition indicated.
- H. Water-Repellent Admixture: Liquid water-repellent mortar admixture intended for use with CMUs containing integral water repellent from same manufacturer.
- I. Water: Potable.

2.05 REINFORCEMENT

- A. Uncoated-Steel Reinforcing Bars: ASTM A615/A615M Grade 60 (Grade 420).
- B. Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells and to hold reinforcing bars in center of cells. Units are formed from 0.148-inch steel wire, hot-dip galvanized after fabrication. Provide units designed for number of bars indicated.
 - 1. Interior Walls: Hot-dip galvanized carbon steel.
 - 2. Exterior Walls: Hot-dip galvanized carbon steel.
 - 3. Wire Size for Side Rods: 0.148-inch diameter.
 - 4. Size for Cross Rods: 0.148-inch diameter.
 - 5. Wire Size for Veneer Ties: 0.148-inch diameter.
 - 6. Spacing of Cross Rods, Tabs, and Cross Ties: Not more than 16 inches o.c.
 - 7. Provide in lengths of not less than 10 ft. (3 m), with prefabricated corner and tee units.
 - 8. Ladder type with one side rod at each face shell of hollow masonry units more than 4 inches wide, plus one side rod at each wythe of masonry 4 inches wide or less.

2.06 TIES AND ANCHORS

- A. General: Ties and anchors shall extend at least 1-1/2 inches into veneer but with at least a 5/8-inch cover on outside face.
- B. Materials: Provide ties and anchors specified in this article that are made from materials that comply with the following unless otherwise indicated:
 - 1. Hot-Dip Galvanized, Carbon-Steel Wire: ASTM A1064/A1064M, with ASTM A153/A153M, Class B-2 coating.
 - 2. Stainless Steel Wire: ASTM A580/A580M, Type 304.
- C. Corrugated-Metal Ties: Metal strips not less than 7/8 inch wide with corrugations having a wavelength of 0.3 to 0.5 inch and an amplitude of 0.06 to 0.10 inch made from 0.0336-inch thick steel sheet, galvanized after fabrication.

2.07 EMBEDDED FLASHING

- A. Metal Flashing: Provide metal flashing complying with SMACNA's "Architectural Sheet Metal Manual" and as follows:
 - 1. Stainless Steel: ASTM A240/A240M or ASTM A666, Type 304 Type 316, 0.016 inch thick.
 - 2. Fabricate continuous flashings in sections 96 inches long minimum, but not exceeding 12 ft. Provide splice plates at joints of formed, smooth metal flashing.
- B. Solder and Sealants for Sheet Metal Flashings.
 - 1. Solder for Stainless Steel: ASTM B32, Grade Sn60, with acid flux of type recommended by stainless steel sheet manufacturer.

2. Elastomeric Sealant: ASTM C920, chemically curing urethane, polysulfide or silicone sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and remain watertight.

2.08 ACCESSORIES

- A. Compressible Filler: Premolded filler strips complying with ASTM D1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from neoprene.
- B. Bond-Breaker Strips: Asphalt-saturated felt complying with ASTM D226/D226M, Type I (No. 15 asphalt felt).

2.09 MORTAR AND GROUT MIXES

- A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.
 1. Do not use calcium chloride in mortar or grout.
 2. Use portland cement-lime mortar unless otherwise indicated.
 3. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.
- B. Preblended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.
- C. Mortar for Unit Masonry: Comply with ASTM C270, Proportion Specification. Provide the following types of mortar for applications stated unless another type is indicated or needed to provide required compressive strength of masonry.
 1. For masonry below grade or in contact with earth, use Type M.
 2. For reinforced masonry, use Type N.
 3. For exterior, above-grade, load-bearing, nonload-bearing walls, and parapet walls; for interior load-bearing walls; for interior nonload-bearing partitions; and for other applications where another type is not indicated, use Type N.
- D. Pigmented Mortar: Use colored cement product or select and proportion pigments with other ingredients to produce color required. Do not add pigments to colored cement products.
 1. Pigments shall not exceed 10 percent of portland cement by weight.
 2. For carbon-black pigment and portland cement-lime mortar, not more than 2 percent.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 - 1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
 - 2. Verify that foundations are within tolerances specified.
 - 3. Verify that reinforcing dowels are properly placed.
 - 4. Verify that substrates are free of substances that impair mortar bond.
- B. Before installation, examine rough-in and built-in construction for piping systems to verify actual locations of piping connections.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION, GENERAL

- A. Thickness: Build cavity and composite walls and other masonry construction to full thickness shown. Build single-wythe walls to actual widths of masonry units, using units of widths indicated.
- B. Build chases and recesses to accommodate items specified in this and other Sections.
- C. Leave openings for equipment to be installed before completing masonry. After installing equipment, complete masonry to match construction immediately adjacent to opening.
- D. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.
- E. Select and arrange units for exposed unit masonry to produce a uniform blend of colors and textures. Mix units from several pallets or cubes as they are placed.
- F. Matching Existing Masonry: Match coursing, bonding, color, and texture of existing masonry.
- G. Wetting of Brick: Wet brick before laying if initial rate of absorption exceeds 30 g/30 sq. in. (30 g/194 sq. cm) per minute when tested in accordance with ASTM C67/C67M. Allow units to absorb water so they are damp but not wet at time of laying.

3.03 TOLERANCES

- A. Dimensions and Locations of Elements:
 - 1. For dimensions in cross section or elevation, do not vary by more than plus 1/2 inch or minus 1/4 inch.

2. For location of elements in plan, do not vary from that indicated by more than plus or minus 1/2 inch.
3. For location of elements in elevation, do not vary from that indicated by more than plus or minus 1/4 inch in a story height or 1/2 inch total.

B. Lines and Levels:

1. For bed joints and top surfaces of bearing walls, do not vary from level by more than 1/4 inch in 10 ft., or 1/2-inch maximum.
2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8 inch in 10 ft., 1/4 inch in 20 ft., or 1/2-inch maximum.
3. For vertical lines and surfaces, do not vary from plumb by more than 1/4 inch in 10 ft., 3/8 inch in 20 ft., or 1/2-inch maximum.
4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8 inch in 10 ft., 1/4 inch in 20 ft., or 1/2-inch maximum.
5. For lines and surfaces, do not vary from straight by more than 1/4 inch in 10 ft., 3/8 inch in 20 ft., or 1/2-inch maximum.
6. For vertical alignment of exposed head joints, do not vary from plumb by more than 1/4 inch in 10 ft., or 1/2-inch maximum.

C. Joints:

1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8 inch, with a maximum thickness limited to 1/2 inch.
2. For exposed bed joints, do not vary from bed-joint thickness of adjacent courses by more than 1/8 inch.
3. For head and collar joints, do not vary from thickness indicated by more than plus 3/8 inch or minus 1/4 inch.
4. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch. Do not vary from adjacent bed-joint and head-joint thicknesses by more than 1/8 inch.
5. For exposed bed joints and head joints of stacked bond, do not vary from a straight line by more than 1/16 inch from one masonry unit to the next.

3.04 LAYING MASONRY WALLS

- A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.
- B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in running bond; do not use units with less-than-nominal 4-inch horizontal face dimensions at corners or jambs.
- C. Lay concealed masonry with all units in a wythe in running bond or bonded by lapping not less than 4 inches. Bond and interlock each course of each wythe at corners. Do not use units with less-than-nominal 4-inch horizontal face dimensions at corners or jambs.

- D. Stopping and Resuming Work: Stop work by stepping back units in each course from those in course below; do not tooth. When resuming work, clean masonry surfaces that are to receive mortar, remove loose masonry units and mortar, and wet brick if required before laying fresh masonry.
- E. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.
- F. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of metal lath, wire mesh, or plastic mesh in the joint below, and rod mortar or grout into core.
- G. Fill cores in hollow CMUs with grout 24 inches under bearing plates, beams, lintels, posts, and similar items unless otherwise indicated.
- H. Build nonload-bearing interior partitions full height of story to underside of solid floor or roof structure above unless otherwise indicated.
 - 1. Install compressible filler in joint between top of partition and underside of structure above.
 - 2. Fasten partition top anchors to structure above and build into top of partition. Grout cells of CMUs solidly around plastic tubes of anchors, and push tubes down into grout to provide 1/2-inch clearance between end of anchor rod and end of tube. Space anchors 48 inches o.c. unless otherwise indicated.

3.05 MORTAR BEDDING AND JOINTING

- A. Lay CMUs as follows:
 - 1. Bed face shells in mortar and make head joints of depth equal to bed joints.
 - 2. Bed webs in mortar in all courses of piers, columns, and pilasters.
 - 3. Bed webs in mortar in grouted masonry, including starting course on footings.
 - 4. Fully bed entire units, including areas under cells, at starting course on footings where cells are not grouted.
 - 5. Fully bed units and fill cells with mortar at anchors and ties as needed to fully embed anchors and ties in mortar.
- B. Lay solid masonry units with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not deeply furrow bed joints or slush head joints.
- C. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.
 - 1. For glazed masonry units, use a nonmetallic jointer 3/4 inch or more in width.
- D. Cut joints flush for masonry walls to receive plaster or other direct-applied finishes (other than paint) unless otherwise indicated.

3.06 CAVITY WALLS

- A. Bond wythes of cavity walls together as follows:

1. Masonry-Joint Reinforcement: Installed in horizontal mortar joints.
 - a. Where bed joints of both wythes align, use ladder-type reinforcement extending across both wythes.
 - b. Where bed joints of wythes do not align, use adjustable-type (two-piece-type) reinforcement with continuous horizontal wire in facing wythe attached to ties.
- B. Keep cavities clean of mortar droppings and other materials during construction. Bevel beds away from cavity, to minimize mortar protrusions into cavity. Do not attempt to trowel or remove mortar fins protruding into cavity.

3.07 MASONRY-JOINT REINFORCEMENT

- A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8 inch on exterior side of walls, 1/2 inch elsewhere. Lap reinforcement a minimum of 6 inches.
- B. Interrupt joint reinforcement at control and expansion joints unless otherwise indicated.
- C. Provide continuity at wall intersections by using prefabricated T-shaped units.
- D. Provide continuity at corners by using prefabricated L-shaped units.
- E. Cut and bend reinforcing units as directed by manufacturer for continuity at corners, returns, offsets, column fireproofing, pipe enclosures, and other special conditions.

3.08 ANCHORING MASONRY TO STRUCTURAL STEEL AND CONCRETE

- A. Anchor masonry to structural steel and concrete, where masonry abuts or faces structural steel or concrete, to comply with the following:
 1. Provide an open space not less than 1/2 inch wide between masonry and structural steel or concrete unless otherwise indicated. Keep open space free of mortar and other rigid materials.
 2. Anchor masonry with anchors embedded in masonry joints and attached to structure.
 3. Space anchors as indicated, but not more than 24 inches o.c. vertically and 36 inches o.c. horizontally.

3.09 CONTROL AND EXPANSION JOINTS

- A. General: Install control- and expansion-joint materials in unit masonry as masonry progresses. Do not allow materials to span control and expansion joints without provision to allow for in-plane wall or partition movement.
- B. Form control joints in concrete masonry as follows:
 1. Fit bond-breaker strips into hollow contour in ends of CMUs on one side of control joint. Fill resultant core with grout, and rake out joints in exposed faces for application of sealant.

3.10 LINTELS

- A. Install steel lintels where indicated.
- B. Provide masonry lintels where indicated and where openings of more than 12 inches for brick-size units and 24 inches for block-size units are indicated without structural steel or other supporting lintels.
- C. Provide minimum bearing of 8 inches at each jamb unless otherwise indicated.

3.11 REINFORCED UNIT MASONRY

- A. Temporary Formwork and Shores: Construct formwork and shores as needed to support reinforced masonry elements during construction.
 - 1. Construct formwork to provide shape, line, and dimensions of completed masonry as indicated. Make forms sufficiently tight to prevent leakage of mortar and grout. Brace, tie, and support forms to maintain position and shape during construction and curing of reinforced masonry.
 - 2. Do not remove forms and shores until reinforced masonry members have hardened sufficiently to carry their own weight and that of other loads that may be placed on them during construction.
- B. Placing Reinforcement: Comply with requirements in TMS 602.
- C. Grouting: Do not place grout until entire height of masonry to be grouted has attained enough strength to resist grout pressure.
 - 1. Comply with requirements in TMS 602 for cleanouts and for grout placement, including minimum grout space and maximum pour height.
 - 2. Limit height of vertical grout pours to not more than 60 inches.

3.12 REPAIRING, POINTING, AND CLEANING

- A. Remove and replace masonry units that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Install new units to match adjoining units; install in fresh mortar, pointed to eliminate evidence of replacement.
- B. Pointing: During the tooling of joints, enlarge voids and holes, except weep holes, and completely fill with mortar. Point up joints, including corners, openings, and adjacent construction, to provide a neat, uniform appearance. Prepare joints for sealant application, where indicated.
- C. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.
- D. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:
 - 1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.

2. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before proceeding with cleaning of masonry.
3. Protect adjacent stone and nonmasonry surfaces from contact with cleaner by covering them with liquid strippable masking agent or polyethylene film and waterproof masking tape.
4. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
5. Clean concrete masonry by applicable cleaning methods indicated in NCMA TEK 8-4A.

3.13 MASONRY WASTE DISPOSAL

- A. Salvageable Materials: Unless otherwise indicated, excess masonry materials are Contractor's property. At completion of unit masonry work, remove from Project site.
- B. Waste Disposal as Fill Material: Dispose of clean masonry waste, including excess or soil-contaminated sand, waste mortar, and broken masonry units, by crushing and mixing with fill material as fill is placed.
 1. Crush masonry waste to less than 4 inches in each dimension.
 2. Do not dispose of masonry waste as fill within 18 inches of finished grade.
- C. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, as described above or recycled, and other masonry waste, and legally dispose of off Owner's property.

3.14 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 05051

ANCHOR BOLTS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This section specifies anchor bolts and embedded anchorages into concrete.

1.02 RELATED WORK

- A. Division 3 – Concrete
- B. Division 5 – Metals
- C. Division 11 – Equipment
- D. Division 15 – Mechanical
- E. Coordinate work of this section with all other sections to obtain a proper installation. Review all Drawings and specifications for additional requirements for anchor bolts and anchorages.

1.03 REFERENCE STANDARDS

- A. American Institute of Steel Construction (AISC).
 - 1. AISC 303: Code of Standard Practice for Structural Steel Buildings and Bridges.
 - 2. AISC 360: Specifications for Structural Steel Buildings.
 - 3. Steel Construction Manual.
- B. American Concrete Institute (ACI)
 - 1. ACI 318: Building Code Requirements for Structural Concrete
 - 2. ACI 350: Code Requirements for Environmental Engineering Concrete Structures
- C. International Code Council
 - 1. International Building Code (IBC)
- D. American Society of Civil Engineers (ASCE)
 - 1. ASCE-7: Minimum Design Loads for Buildings and Other Structures
- E. American Society for Testing and Materials (ASTM):
 - 1. ASTM A36 – Standard Specification for Carbon Structural Steel.
 - 2. ASTM A123 – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 3. ASTM A153 – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 4. ASTM A193 – Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.

5. ASTM A194 – Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
6. ASTM A307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
7. ASTM A325 – Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
8. ASTM A490 – Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.
9. ASTM A563 – Standard Specification for Carbon and Alloy Steel Nuts.
10. ASTM A780 – Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
11. ASTM F593 – Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
12. ASTM F594 – Standard Specification for Stainless Steel Nuts.

1.04 SUBMITTALS

A. Shop Drawings:

1. Submit shop drawings as specified in Division 1, General Provisions. Give sufficient detail to permit anchor bolt installation without referring to design Drawings.
2. Drawings must include all anchor bolts and embedded anchorages, bolt setting and erection templates.
3. Provide Manufacturer's specifications, load tables and installation instructions.
4. Erection drawings shall be sealed by a Licensed Professional Engineer in the State in which the project is will be built.
5. Provide a letter sealed by a Licensed Professional Engineer in the State of Texas stating that all anchor bolts and anchorages not specifically shown on the structural Drawings are adequate for the application and meet all design requirements in the Drawings and referenced codes.

1.05 PRODUCT DELIVERY AND STORAGE

- ##### A.
- If materials must be stored, keep them off the ground and clean, free of dirt, mud, grease or oil. Protect bolts and anchorages from corrosion and/or deterioration.

PART 2 PRODUCTS

2.01 DESIGN CRITERIA

- ##### A.
- When the size, length, and material or load carrying capacity of the anchor bolts or anchorages are not shown in the Drawings, provide the following:
1. For cast-in-place anchor bolts or anchorages:
 - a. Provide the material type, size, length, and arrangement required to resist all loads and load combinations given in the latest version of the IBC Building Code, ASCE-07 and the Drawings. In the case of conflicting requirements, the most restrictive requirements will control.
 2. For post-installed anchor bolts or anchorages:

- a. Provide the material type, size, length, minimum embedment and arrangement required to resist all loads and load combinations given in the latest version of the IBC Building Code, ASCE-07 and the Drawings. In the case of conflicting requirements, the most restrictive requirements will control.
- b. Provide required adhesive and installation requirements.

2.02 MATERIALS

A. Anchor Bolts:

1. Provide anchor bolts as shown in the Drawings.
2. Provide stainless steel anchor bolts and hardware complying with ASTM F593, AISI Type 316 headed with stainless steel nuts and washers.
3. For equipment, provide 316 stainless steel anchor bolts that meet the Manufacturer's requirements for size and strength. Comply with Manufacturer's requirements for embedment length and projection.
4. Protect threads and shank from damage during placement of concrete, installation of equipment and erection of structural steel.

B. Adhesive Anchors:

1. Provide stainless steel adhesive anchors and hardware complying with ASTM F593, Condition CW, AISI Type 316 headed with stainless steel nuts and washers.
2. Adhesive system shall be Hilti HIT-HY200 adhesive by Hilti or approved equal.
3. Embedment depth of the anchor shall provide pullout strength equal to the allowable tensile capacity of the anchor, unless otherwise noted in the Drawings. Reduction in pullout strength due to spacing and edge distances shall be made.

C. Expansion Anchors

1. Expansion anchors will not be allowed structural connections unless specifically called for in the Drawings.
2. Where expansion anchors are called for in other sections, provide Type 316 stainless steel expansion anchors.
 - a. Kwik Bolt by Hilti
 - b. Easy-Set by Simpson

PART 3 EXECUTION

3.01 INSTALLATION

- A. Assure that embedded items are protected from damage and are not filled in with concrete.
- B. Set bolts as show in the Drawings or as required using templates or other devices to insure accurate placement and to prevent drift during concrete placement.
- C. Fully consolidate plastic concrete around anchor bolts per the requirements Division 3 Specifications.

- D. For adhesive anchors and adhesive materials, CONTRACTOR shall comply with all Manufacturer's installation instructions. Properly clean out holes per Manufacturer's required procedures prior to installation of adhesive.

3.02 CLEANING

- A. After Embedding concrete is placed, remove protection and clean bolts and inserts.

3.03 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 05500

MISCELLANEOUS METAL FABRICATIONS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This section specifies metal elements including but not limited to the following. All items listed are not necessarily included in the project, see Project Drawings for specific project requirements.
 - 1. Shelf angles.
 - 2. Steel framing and supports for equipment and where framing and supports are not specified in other Sections.
 - 3. Pipe bollards.
 - 4. Prefabricated access hatches.
 - 5. Aluminum construction, including:
 - a. Aluminum ladders.
 - b. Aluminum handrails and railings.
 - c. Aluminum stairs and platforms.

1.02 RELATED WORK

- A. Division 3 – Concrete
- B. Division 5 – Metals
- C. Division 9 - Coatings

1.03 REFERENCE STANDARDS

- A. International Code Council
 - 1. International Building Code (IBC)
- B. American Society of Civil Engineers (ASCE)
 - 1. ASCE-7: Minimum Design Loads for Buildings and Other Structures
- C. The Aluminum Association
 - 1. Aluminum Design Manual.
- D. American Institute of Steel Construction (AISC).
 - 1. Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings.
 - 2. Steel Construction Manual.
 - 3. Code of Standard Practice.
 - 4. Design Guide 27 – Structural Stainless Steel.
- E. American Welding Society (AWS):
 - 1. D1.1 Structural Welding Code - Steel.

2. D1.2 Structural Welding Code – Aluminum
 3. D1.3 Structural Welding Code – Sheet Steel
 4. D1.6 Structural Welding Code – Stainless
- F. American Society for Testing and Materials (ASTM):
1. ASTM A36 - Standard Specification for Carbon Structural Steel.
 2. ASTM A48 - Standard Specification for Gray Iron Castings.
 3. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 4. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 5. ASTM A108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
 6. ASTM A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 7. ASTM A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 8. ASTM A240 – Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for pressure Vessels and General Applications.
 9. ASTM A276 - Standard Specification for Stainless Steel Bars and Shapes.
 10. ASTM A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
 11. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
 12. ASTM A490 - Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.
 13. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
 14. ASTM A572 - Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
 15. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 16. ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
 17. ASTM A992 - Standard Specification for Structural Steel Shapes.
 18. ASTM A1008 - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
 19. ASTM A1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
 20. ASTM B26, Specification for Aluminum and Aluminum-Alloy Sand Castings.
 21. ASTM B136, Method for Measurement of Stain Resistance of Anodic Coatings on Aluminum.

22. ASTM B137, Test Method for Measurement of Coating Mass Per Unit Area of Anodically Coated Aluminum.
23. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
24. ASTM B210, Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes.
25. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
26. ASTM B241, Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube.
27. ASTM B244, Test Method for Measurement of Thickness of Anodic Coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments.
28. ASTM B247, Specification for Aluminum and Aluminum-Alloy Die Forgings, Hand Forgings, and Rolled Ring Forgings.
29. ASTM B429, Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
30. ASTM F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

G. The American Society of Safety Engineers (ASSE)

1. ASSE A1264.1, Safety Requirements for Workplace Walking/Working Surfaces & Their Access; Workplace Floor, Wall & Roof Openings; Stairs & Guardrails Systems

H. The Coatings Society (SSPC):

1. SSPC Painting Manual, Volumes 1 & 2.

I. Research Council on Riveted and Bolted Structural Joints (RCRBSJ):

1. Specification for Structural Joints Using ASTM A325 or A490 Bolts.

J. United States Department of Labor:

1. OSHA Regulations (Standards - 29 CFR); Part 1926 - Safety and Health Regulations for Construction.

1.04 SUBMITTALS

A. Shop Drawings:

1. Submit shop drawings as specified in Division 1, General Provisions.
2. Submit detailed shop drawings showing sizes of members, method of assembly, anchorage, and connection to other members for approval prior to fabrication.
3. Provide a letter sealed by a Licensed Professional Engineer in the State which the project will be built stating that all connections not specifically shown on the design structural Drawings have been designed and detailed under their supervision.

B. Certificates: Submit certified mill reports from the material supplier. Reports must provide heat or melt number mill analysis and test results for structural steel. If

reports are not submitted or if the material cannot be positively identified and directly related to the reports, material quality tests will be required at no cost to the OWNER.

1.05 COORDINATION

- A. The Work of this Section shall be completely coordinated with the Work of other Sections. Verify at the Site the dimensions and the Work of other trades adjoining items of Work in this Section before fabricating or installing the items specified.
- B. Furnish to the pertinent trades all items included under this Section that are to be built into the Work of other Sections.

1.06 PRODUCT DELIVERY AND STORAGE

- A. Schedule material delivery so that items may be installed promptly after arrival.
- B. If materials must be stored, keep them off the ground and clean, free of dirt, mud, grease or oil. Store in such a manner to avoid member distortion. Protect steel from corrosion and/or deterioration.

PART 2 PRODUCTS

2.01 GENERAL

- A. For metal fabrications exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

2.02 ALUMINUM

- A. Materials
 - 1. Aluminum structural shapes, bars and plates:
 - a. Alloy 6061-T6.
 - 2. Extruded aluminum pipe:
 - a. Alloy 6063-T6 or 6061-T6.
 - 3. Aluminum Castings:
 - a. Alloy 535.
 - 4. Stainless steel fasteners:
 - a. ASTM 276, Type 316.
- B. Fabrication
 - 1. Follow general fabrication requirements elsewhere in this Section.
 - 2. Fabricate miscellaneous aluminum shapes and plates as shown. Furnish welded and mitered angle frames and other fabrications complete with welded anchors attached. Furnish all miscellaneous aluminum shown but not otherwise detailed. Structural shapes and extruded items shall comply with the dimensions on the Drawings within the tolerances published by the Aluminum Association.
 - 3. Weld aluminum work on the unexposed side when possible in order to prevent pitting or discoloration of exposed aluminum surfaces.

- C. Finishes
 - 1. All exposed aluminum surfaces shall have fabricator's standard mill finish unless otherwise specified. Apply a coat of methacrylate lacquer to all aluminum before shipment.

2.03 FERROUS METALS

- A. Structural Steel:
 - 1. All rolled structural shapes, plates and bars must meet the standards for ASTM A992 and ASTM A572, Grade 50.
 - 2. Clip angles, stiffeners, plates and other detail items must conform to standards of the main member to which the items are attached unless noted otherwise.
- B. Steel Pipe
 - 1. Conform to ASTM A53, Type E or S, Grade B, welded or seamless. No hydrostatic tests required.
- C. Structural steel tubing:
 - 1. Conform to ASTM A500, Grade B, with minimum yield strength of 46,000 psi.
- D. Stainless Steel:
 - 1. Use the stainless steel grade indicated on the Drawings (304 or 316). Where the grade is not specified use AISI 316. Use a weldable (304L or 316L) grade of stainless steel for welded items.
 - 2. For all stainless steel, required yield strength is 50,000 psi unless otherwise noted in the Drawings.
- E. Slotted Channel Framing:
 - 1. Galvanized steel cold-formed metal channels with flange edges returned toward web and with 9/16-inch wide slotted holes in webs at 2 inches on center.
 - 2. Channel width:
 - a. as indicated on the Drawings.
 - 3. Channel depth:
 - a. as indicated on the Drawings.
- F. Gray-Iron Castings:
 - 1. Gray iron castings conforming to ASTM A48, Class 30 unless another class is indicated or required by structural loads.

2.04 FASTENERS:

- A. Provide ASTM F593, Type 316 fasteners for exterior use or when called for in the Drawings.
- B. Structural Steel Bolts, Nuts & Washers
 - 1. Bolts & Nuts:
 - a. Use high-strength bolts, conforming to ASTM A325 with hex nuts.
 - 2. Washers

- a. plain washers, use round, carbon steel, ASME B18.22.1.
- b. lock washers, use helical, spring type, carbon steel , ASME B18.22.1.

2.05 SHELF ANGLES

- A. Fabricate shelf angles from steel angles of sizes indicated and for attachment to concrete framing. Provide horizontally slotted holes to receive 3/4-inch bolts, spaced not more than 6 inches from ends and 24 inches o.c., unless otherwise indicated in the Drawings.
- B. For cavity walls, provide vertical channel brackets to support angles from backup masonry and concrete. Align expansion joints in angles with indicated control and expansion joints in cavity-wall exterior wythe.
- C. Galvanized shelf angles to be installed in exterior walls.
- D. Furnish wedge-type concrete inserts, complete with fasteners, to attach shelf angles to cast-in-place concrete unless otherwise indicated in the Drawings.

2.06 PIPE BOLLARDS

- A. Fabricate pipe bollards from Schedule 80 steel pipe. Cap bollards consistent with details in the Drawings.
- B. Where indicated, fabricate bollards with steel baseplates for bolting to concrete slab. Drill baseplates at all four corners for anchor bolts. Base plate and anchor bolts size shall be as shown on Drawings. Where bollards are to be anchored to sloping concrete slabs, angle base plates for plumb alignment of bollards.

2.07 PREFABRICATED ACCESS HATCHES

- A. Hatches:
 - 1. General Requirements:
 - a. Provide prefabricated access hatches of the sizes and types shown on the Drawings.
 - b. Door leaf(s) shall be aluminum diamond plate as shown on Drawings.
 - c. Unless otherwise noted on the Drawings, use pivot torsion bars for counterbalance or spring operators for easy operation. Doors shall open to 90 degrees with automatic door hold open and shall be provided with a grip handle to release the cover for closing.
 - d. Hardware shall be durable and corrosion resistant with Type 316 stainless steel hardware used throughout. Provide removable lock handle.
 - e. Provide factory mill finish and bituminous coating to the exterior of the frames. Where specified to be watertight, a 1-1/2-inch drainage coupling shall be provided in the perimeter channel frame.
 - f. Break bond between dissimilar metals using a heavy coat of alkali resistant bituminous paint, or other coating recommended by the Manufacturer that will provide equivalent protection. Otherwise, hatches used at exposed exterior locations shall be weather stripped or sealed to resist penetration of

water. Embedded frame with embedment anchors shall be supplied by the hatch Manufacturer.

- g. Manufacturers shall provide access hatch with aluminum safety grating panel installed beneath access covers to provide additional protection against fall through accidents when the cover is left in the open position. The aluminum grating panel shall be designed, anchored, etc., by Hatch Manufacturer.
- 2. Load Requirements:
 - a. Pedestrian Access Only:
 - (i) Hatches subjected to pedestrian access only shall be designed to withstand an unfactored live load of 300 pounds per square foot.
 - b. Vehicular Access:
 - (i) Hatches subjected to vehicular traffic shall be designed to withstand an unfactored concentrated wheel loading (live load) of 16,000 lbs or an unfactored live load of 300 pounds per square foot, whichever produces the greatest stresses.
- 3. Acceptable Manufacturers: Subject to compliance with requirements, provide prefabricated roof hatch units by one of the following:
 - a. Halliday Products, Inc., Orlando, FL.
 - b. Bilco Company; New Haven, CT.
 - (i) Type J for Single Leaf.
 - (ii) Type JD for Double Leaf.

B. Roof Scuttles: Materials and Fabrication

- 1. General Requirements:
 - a. Provide prefabricated roof scuttles of the sizes and types shown on the Drawings.
- 2. Cover:
 - a. Galvanized steel with 3-inch bedded flange, neatly welded. Curb shall be 12-inch in height and galvanized steel.
 - b. Cover shall be equipped with an automatic hold-open arm complete with vinyl grip handle to permit easy release.
 - c. Equip units with complete hardware set including padlock, and both interior and exterior hatch handles. All hardware shall be Type 316 stainless steel.
- 3. Provide factory mill finish and bituminous coating to the exterior of the frames. Break bond between dissimilar metals as specified for Hatches.
- 4. Roof Scuttles shall be weather stripped or sealed to resist penetration of water as required. Embedded frame with embedment anchors shall be supplied by the Manufacturer.
- 5. Acceptable Manufacturers: Subject to compliance with requirements, provide prefabricated roof scuttle units by one of the following:
 - a. Halliday Products, Inc., Orlando, FL.
 - b. Bilco Company; New Haven, CT.

2.08 ALUMINUM LADDERS

A. Performance Criteria

1. Fixed ladders and side extensions shall meet the load requirements of ASCE-7, Section 4.5.4.
2. Fixed ladders and accessories shall be certified as meeting current requirements of IBC, ASCE-7 and OSHA.

B. Materials:

1. Side Rails/Safety Cages, Rail Extension, and Platform:
 - a. Aluminum plates, alloy 6061-T6
 - b. Aluminum extrusions, alloy 6063-T5.
2. Rungs:
 - a. Knurled or serrated aluminum bars, 1.25-inch in square section, alloy 6061-T6.
 - b. Weld size and filler material shall meet required design strength.
3. Rail Extension:
 - a. Minimum 3'-6" above the landing and shall be fitted with deeply serrated, square, tubular grab rails.
4. Safety cage:
 - a. Provide safety cage on all ladders over 20 feet unless otherwise noted in the Drawings.
5. Landing Platform:
 - a. Provide at 30 foot intervals above the bottom of the ladder, complete with 1-1/2 inch or greater diameter tubular aluminum guard rails and decks of serrated aluminum treads.
6. Wall/Floor Support Brackets.:
 - a. Aluminum plates, alloy 6061-T6.
 - b. 316 SS fasteners/rigid attack/locking.

C. Acceptable Manufacturers:

1. O'Keefe's.
2. Alaco.

D. Ladder safety post extensions

1. Each fixed ladder occurring below a hatch door shall be provided with an attached telescoping safety post extension of aluminum construction. Unit shall be completely assembled with stainless steel fasteners and brackets for securing to the ladder rungs provided by the Manufacturer.
2. Acceptable Manufacturers: Bilco - Ladder Up Safety Post, Model 2; or equal.

2.09 ALUMINUM HANDRAILS & RAILINGS

A. General:

1. Comply with handrail and railing system details shown on the Drawings. Provide fabricator's standard details for conditions not shown on the Drawings and for

general system assembly, unless otherwise specified. All details shown are typical; similar details apply to similar conditions, unless specifically otherwise shown on the Drawings.

2. Where details show post location requirements at or near end of runs, uniformly space intermediate posts as required to meet loading and deflection criteria specified, but not greater than maximum spacing specified. Where posts are shown at straight walkways and other locations where railing is provided on each side, locate railing system posts opposite each other; do not stagger.
3. Where sizes are shown on the Drawings, the sizes shown shall be considered minimum. Increase size to comply with required system performance criteria loadings and minimum safety factor specified.
4. CONTRACTOR may propose alternative proprietary handrail system for ENGINEER's approval. The proposed system shall meet all performance criteria and code requirements within or referenced by this Specification.

B. Allowable Tolerances:

1. Limit variation of cast-in-place inserts, sleeves and field-drilled anchor and fastener holes to the following:
 - a. Spacing: $\pm 3/8$ -inch.
 - b. Alignment: $\pm 1/4$ -inch.
 - c. Plumbness: $\pm 1/8$ -inch.
2. Minimum Handrails and Railings Systems Plumb Criteria:
 - a. Limit variation of completed handrail and railing system alignment to $1/4$ -inch in 12 feet - 0 inches with posts set plumb to within $1/16$ -inch in 3 foot - 0 inches.
 - b. Align rails so variations from level for horizontal members and from parallel with rake of stairs and ramps for sloping members do not exceed $1/4$ -inch in 12 feet - 0 inches.
3. Provide "pencil-line" thin butt joints.

C. Performance Criteria:

1. Handrails, toeboards and all other related components shall meet:
 - a. Code requirements of IBC Section 1012
 - b. Load requirements of ASCE-7, Section 4.5.1.
 - c. OSHA Regulations Standard 1926.502.
2. If there is a conflict between code requirements the more stringent requirements shall apply.
3. Handrails, toeboards and all related components shall be certified as meeting all current requirements of IBC, ASCE-7 and OSHA.

D. Expansion Joints:

1. Provide adequate expansion joints within the railing system to accommodate thermal movements by a material temperature range of 120F to 0F without warping or bowing of system components. Distance between expansion joints shall be based on providing a $1/4$ -inch wide joint at 70F, which accommodates a

movement of 150 percent of the calculated amount of movement for the specified temperature range.

2. Provide expansion joints in handrail and railing systems where systems cross expansion joints in structure.

E. Materials:

1. Aluminum structural shapes, bars and plates:
 - a. Alloy 6061-T6.
2. Extruded aluminum pipe:
 - a. Alloy 6063-T6 or 6061-T6.
3. Aluminum Castings:
 - a. Alloy 535.
4. All materials shall be provided with an anodized finish.

F. Gates:

1. Hinges: Provide two self-closing aluminum hinges for each railing system gate shown on the Drawings.
2. Latches and Stops: Provide one latch and stop with rubber bumper and 1-inch diameter plastic knob for each railing system gate shown on the Drawings.

G. Fabrication:

1. Close aluminum pipe ends by using prefabricated fittings.
2. Remove burrs from all exposed edges.
3. Weep Holes:
 - a. Fabricate joints, which will be exposed to the weather so as to exclude water.
 - b. Provide 1/4-inch diameter weep holes at the lowest possible point on all handrail and railing systems posts.
 - c. Provide pressure relief holes at closed ends of handrail and railing systems.
4. All railing system posts shall be provided with a circular profile solid reinforcing bar with outside diameter equal to inside diameter of post. Each post shall receive one reinforcing bar.

2.10 GALVANIZING

- A. Hot-dipped zinc coat structural items specifically designated as galvanized after fabrication. Conform to the applicable standard, ASTM A123 or ASTM A153.
- B. Use repair coating which conforms to ASTM A780. Acceptable products include:
 1. Carboline Carbo Zinc No. 11.
 2. Galv-Weld Products Galv-Weld Alloy.
 3. Koppers Organic Zinc coating.
- C. Unless otherwise noted all structural steel shall be galvanized.

2.11 FABRICATION

- A. Begin fabrication of items only after shop drawings have been reviewed with no exceptions taken. Fabricate according to industry reference standards, codes, and these specifications unless directed or shown otherwise.
- B. Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- C. Shear and punch metals cleanly and accurately. Remove burrs.
- D. Ease exposed edges to a radius of approximately 1/32-inch (1 mm), unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- E. Weld corners and seams continuously to comply with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- F. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
- G. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
- H. Fabricate joints that will be exposed to weather in a manner to exclude water, or provide weep holes where water may accumulate.
- I. Allow for thermal movement resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening up of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
- J. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges.
- K. Remove sharp or rough areas on exposed traffic surfaces.

- L. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous.

2.12 WELDING

- A. Perform welding in accord with the AWS reference standard. Use procedures such as preheat or interpass temperature as recommended by AWS standards.
- B. All shop and field welding must be performed by qualified welders who hold current welding certificates.
- C. Surfaces to be welded must be free of loose scale, slag, rust, grease, paint and other foreign material. Mill scale which withstands vigorous wire brushing may remain.
- D. Joint surfaces must be free of fins and tears caused by shearing. Wherever practicable, prepare edges by gas cutting using a mechanically guided torch.
- E. Electrodes:
 - 1. For structural steel, use AWS Low Hydrogen, Electrode E70XX Series suitable for the welding process used.
 - 2. For stainless steel, use 70 ksi minimum tensile strength filler material suitable for base metals and welding process in accordance with AWS specifications.
 - 3. For aluminum, use filler alloy 5356 in accordance with AWS specifications.
 - 4. Protect electrodes from exposure to moisture and coating.
- F. If shop welding is done by automatic, submerged arc process, verify that physical properties of deposited weld metal will be similar to properties of the base metal.
- G. No welding shall be done when the temperature of the base metal is below 32°F.
- H. The cover bead or finish pass must have a smooth, uniform surface with reinforcement of 1/16 to 1/8 inch. Surface voids, cracks in finish weldments, or undercutting of base metal at the fusion line is not acceptable.

2.13 SURFACE PREPARATION AND PAINTING

- A. All surfaces shall be prepared and finished in accordance with Division 9 requirements unless otherwise noted in the Drawings. Structural Steel shall be shop primed. Stainless steel shall not be coated unless otherwise specified in the Drawings or elsewhere in the Specifications.
- B. Galvanize structural steel items specifically shown or specified as galvanized. Members that are warped during the galvanizing process will be rejected.
- C. Aluminum items shall have an anodized finish unless otherwise specified in the Drawings or elsewhere in the Specifications.

2.14 INSPECTION AND TESTING

- A. Mill or shop inspection and non-destructive testing (in addition to field inspection and non-destructive testing) may be done by the OWNER.
- B. Inspection in mill, shop, or field in no way relieves the CONTRACTOR from their responsibility to furnish satisfactory materials. Right is reserved to reject material at any time before final acceptance if material and workmanship do not conform to Drawings and Specifications.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install items according to industry specifications and codes and reviewed shop drawings.
- B. Fastening to In-Place Construction:
 - 1. Provide anchorage devices and fasteners where necessary for securing metal fabrications to in-place construction. Include threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts and other connectors.
- C. Cutting, Fitting, and Placement:
 - 1. Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- D. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- E. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- F. Field Welding: Comply with the following requirements:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

3.02 INSTALLING MISCELLANEOUS FRAMING AND SUPPORTS

- A. General: Install framing and supports to comply with requirements of items being supported, including Manufacturers' written instructions and requirements indicated on shop drawings, if any.

3.03 INSTALLING PIPE BOLLARDS

- A. Anchor bollards in place with concrete footings. Support and brace bollards in position in footing excavations until concrete has been placed and cured.
- B. Fill bollards solidly with concrete, mounding top surface.

3.04 INSTALLING ALUMINUM HANDRAILS & RAILINGS

- A. Install handrails and railings to comply with requirements of the Drawings, Specifications and any Manufacturers' written instructions and requirements.

3.05 INSTALLING LADDERS

- A. Install ladders to comply with requirements of the Drawings, Specifications and any Manufacturers' written instructions and requirements.

3.06 ADJUSTING AND CLEANING

- A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces. Apply by brush or spray to provide a minimum 2.0-mil (0.05mm) dry film thickness.
- B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Section 09900 Painting.
- C. Repair Galvanized Surfaces: Thoroughly Clean field welds, bolted connections, abrasions, abraded areas and galvanized surfaces damaged from welding, handling, or installation shall be repaired immediately after installation with galvanizing repair material. Apply matching galvanized repair coat as specified in Paragraph 2.17.A. Galvanizing repair shall be performed and completed before concrete is placed. Any member requiring repair of more than 2% of the surface area shall be rejected.

3.07 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 05521

METAL RAILINGS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This section specifies aluminum or stainless steel metal railings.

1.02 RELATED WORK

- A. Division 3 – Concrete
- B. Division 5 – Metals
- C. Division 9 – Coatings

1.03 REFERENCE STANDARDS

- A. International Code Council
 - 1. International Building Code (IBC)
- B. American Society of Civil Engineers (ASCE)
 - 1. ASCE-7: Minimum Design Loads for Buildings and Other Structures
- C. The Aluminum Association
 - 1. Aluminum Design Manual.
- D. American Institute of Steel Construction (AISC).
 - 1. Steel Construction Manual.
 - 2. Design Guide 27 – Structural Stainless Steel.
- E. American Welding Society (AWS):
 - 1. D1.2 Structural Welding Code – Aluminum
 - 2. D1.6 Structural Welding Code – Stainless Steel
- F. American Society for Testing and Materials (ASTM):
 - 1. ASTM A193 – Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - 2. ASTM A240 – Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for pressure Vessels and General Applications.
 - 3. ASTM A276 – Standard Specification for Stainless Steel Bars and Shapes.
 - 4. ASTM B26 – Standard Specification for Aluminum-Alloy Sand Castings.
 - 5. ASTM B136 – Standard Method for Measurement of Stain Resistance of Anodic Coatings on Aluminum.
 - 6. ASTM B137 – Standard Test Method for Measurement of Coating Mass Per Unit Area on Anodically Coated Aluminum.
 - 7. ASTM B209 – Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

8. ASTM B210 – Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes.
 9. ASTM B221 – Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
 10. ASTM B241 – Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube.
 11. ASTM B244 – Standard Test Method for Measurement of Thickness of Anodic Coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments.
 12. ASTM B247 – Standard Specification for Aluminum and Aluminum-Alloy Die Forgings, Hand Forgings, and Rolled Ring Forgings.
 13. ASTM B429 – Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
 14. ASTM F593 – Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
 15. ASTM F594 – Standard Specification for Stainless Steel Nuts.
- G. The American Society of Safety Engineers (ASSE)
1. ASSE A1264.1, Safety Requirements for Workplace Walking/Working Surfaces & Their Access; Workplace Floor, Wall & Roof Openings; Stairs & Guardrails Systems
- H. United States Department of Labor:
1. OSHA Regulations (Standards - 29 CFR); Part 1926 - Safety and Health Regulations for Construction.
- 1.04 SUBMITTALS
- A. Shop Drawings:
1. Submit shop drawings as specified in Division 1, General Provisions.
 2. Submit detailed shop drawings showing sizes of members, method of assembly, anchorage, and connection to other members for review prior to fabrication.
- B. Provide a letter sealed by a Licensed Professional Engineer in the State which the project will be built stating that the proposed railing systems and details have been designed and detailed under their supervision and meet all codes referenced by this Section and requirements of this Section.
- C. Certificates: Submit certified mill reports from the material supplier. Reports must provide heat or melt number mill analysis and test results for structural steel. If reports are not submitted or if the material cannot be positively identified and directly related to the reports, material quality tests will be required at no cost to the OWNER.
- 1.05 COORDINATION
- A. The Work of this Section shall be completely coordinated with the Work of other Sections. Verify at the Site the dimensions and the Work of other trades adjoining items of Work in this Section before fabricating or installing the items specified.

- B. Furnish to the pertinent trades all items included under this Section that are to be built into the Work of other Sections.

1.06 PRODUCT DELIVERY AND STORAGE

- A. Schedule material delivery so that items may be installed promptly after arrival.
- B. If materials must be stored, keep them off the ground and clean, free of dirt, mud, grease or oil. Store in such a manner to avoid member distortion. Protect steel from corrosion and/or deterioration.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

2.02 ALUMINUM

- A. Materials
 - 1. Aluminum structural shapes, bars and plates:
 - a. Alloy 6061-T6.
 - 2. Extruded aluminum pipe:
 - a. Alloy 6063-T6 or 6061-T6.
 - 3. Aluminum Castings:
 - a. Alloy 535.
- B. Fabrication
 - 1. Follow general fabrication requirements elsewhere in this Section.
 - 2. Structural shapes and extruded items shall comply with the dimensions on the Drawings within the tolerances published by the Aluminum Association.
 - 3. Weld aluminum work on the unexposed side when possible in order to prevent pitting or discoloration of exposed aluminum surfaces.
- C. Finishes
 - 1. All exposed aluminum surfaces shall have anodized finish unless otherwise specified. Apply a coat of methacrylate lacquer to all aluminum before shipment.

2.03 STAINLESS STEEL

- A. Stainless Steel:
 - 1. Use the stainless steel grade indicated on the Drawings (304 or 316). Where the grade is not specified use AISI 316. Use a weldable (304L or 316L) grade of stainless steel for welded items.
 - 2. For all stainless steel, required yield strength is 50,000 psi unless otherwise noted in the Drawings.
- B. Fabrication
 - 1. Follow general fabrication requirements elsewhere in this Section.

2. Structural shapes shall comply with the dimensions on the Drawings within the tolerances published by AISC.
- C. Finishes
1. All stainless steel surfaces shall have fabricator's standard mill finish unless otherwise specified.
- 2.04 FASTENERS
- A. Provide ASTM F593 and F594, Condition CW, Type 316 anchor bolts, nuts and washers.
- 2.05 ANCHOR BOLTS
- A. Provide ASTM F593 and F594, Condition CW, Type 316 anchor bolts, nuts and washers.
- 2.06 HANDRAILS & RAILINGS
- A. General:
1. Provide handrail and railing system where shown on the Drawings.
 2. Provide a system with three (3) rails and posts with a maximum spacing of four (4) feet. Provide toeboards as required by the referenced codes. The layout and geometry of the system must meet the performance criteria requirements referenced by this Section.
 3. Where geometric requirements result in post locations at or near end of runs, uniformly space intermediate posts as required to meet loading and deflection criteria specified, but not greater than maximum spacing specified. Where posts are required at straight walkways and other locations where railing is provided on each side, locate railing system posts opposite each other; do not stagger.
 4. Provide member sizes and connections to comply with required system performance criteria loadings and minimum safety factor specified in addition to all code requirements within, or referenced by, this Section.
- B. Allowable Tolerances:
1. Limit variation of cast-in-place inserts, sleeves and field-drilled anchor and fastener holes to the following:
 - a. Spacing: $\pm 3/8$ -inch.
 - b. Alignment: $\pm 1/4$ -inch.
 - c. Plumbness: $\pm 1/8$ -inch.
 2. Minimum Handrails and Railings Systems Plumb Criteria:
 - a. Limit variation of completed handrail and railing system alignment to $1/4$ -inch in 12 feet - 0 inches with posts set plumb to within $1/16$ -inch in 3 foot - 0 inches.
 - b. Align rails so variations from level for horizontal members and from parallel with rake of stairs and ramps for sloping members do not exceed $1/4$ -inch in 12 feet - 0 inches.
 3. Provide "pencil-line" thin butt joints.

- C. Performance Criteria:
 - 1. Handrails, railings, toeboards and all other related components shall be certified to meet:
 - a. Code requirements of IBC Section 1012 and 1013.
 - b. Load requirements of ASCE-7, Section 4.5.1.
 - c. OSHA Regulations Standard 1926.502.
 - 2. If there is a conflict between code requirements, the more stringent requirements shall apply.
- D. Expansion Joints:
 - 1. Provide adequate expansion joints within the railing system to accommodate thermal movements by a material temperature range of 120F to 0F without warping or bowing of system components. Distance between expansion joints shall be based on providing a 1/4-inch wide joint at 70F, which accommodates a movement of 150 percent of the calculated amount of movement for the specified temperature range.
 - 2. Provide expansion joints in handrail and railing systems where systems cross expansion joints in structure.
- E. Gates:
 - 1. Hinges: Provide two self-closing hinges for each railing system gate shown on the Drawings.
 - 2. Latches and Stops: Provide one latch and stop with rubber bumper and 1-inch diameter plastic knob for each railing system gate shown on the Drawings.
 - 3. Provide hinges and latches in same material as railing system.
- F. Fabrication:
 - 1. Close pipe ends by using prefabricated fittings.
 - 2. Remove burrs from all exposed edges.
 - 3. Weep Holes:
 - a. Fabricate joints, which will be exposed to the weather so as to exclude water.
 - b. Provide 1/4-inch diameter weep holes at the lowest possible point on all handrail and railing systems posts.
 - c. Provide pressure relief holes at closed ends of handrail and railing systems.
 - 4. All railing system posts shall be provided with a circular profile solid reinforcing bar with outside diameter equal to inside diameter of post. Each post shall receive one reinforcing bar.

2.07 FABRICATION

- A. Begin fabrication of items only after shop drawings have been reviewed with no exceptions taken. Fabricate according to industry reference standards, codes, and these specifications unless directed or shown otherwise.
- B. Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

- C. Shear and punch metals cleanly and accurately. Remove burrs.
 - D. Ease exposed edges to a radius of approximately 1/32-inch (1 mm), unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
 - E. Weld corners and seams continuously to comply with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
 - F. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
 - G. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
 - H. Fabricate joints that will be exposed to weather in a manner to exclude water, or provide weep holes where water may accumulate.
 - I. Allow for thermal movement resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening up of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
 - 1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
 - J. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges.
 - K. Remove sharp or rough areas on exposed traffic surfaces.
 - L. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous.
- 2.08 WELDING
- A. Perform welding in accord with the AWS reference standard. Use procedures such as preheat or interpass temperature as recommended by AWS standards.
 - B. All shop and field welding must be performed by qualified welders who hold current welding certificates.

- C. Surfaces to be welded must be free of loose scale, slag, rust, grease, paint and other foreign material. Mill scale which withstands vigorous wire brushing may remain.
- D. Joint surfaces must be free of fins and tears caused by shearing. Wherever practicable, prepare edges by gas cutting using a mechanically guided torch.
- E. Electrodes:
 - 1. For aluminum, use filler alloy 5356 in accordance with AWS specifications.
 - 2. For stainless steel, use 70 ksi minimum tensile strength filler material suitable for base metals and welding process in accordance with AWS specifications.
 - 3. Protect electrodes from exposure to moisture and coating.
- F. If shop welding is done by automatic, submerged arc process, verify that physical properties of deposited weld metal will be similar to properties of the base metal.
- G. No welding shall be done when the temperature of the base metal is below 32°F.
- H. The cover bead or finish pass must have a smooth, uniform surface with reinforcement of 1/16 to 1/8 inch. Surface voids, cracks in finish weldments, or undercutting of base metal at the fusion line is not acceptable.

2.09 INSPECTION AND TESTING

- A. Mill or shop inspection and non-destructive testing (in addition to field inspection and non-destructive testing) may be done by the OWNER.
- B. Inspection in mill, shop, or field in no way relieves the CONTRACTOR from their responsibility to furnish satisfactory materials. Right is reserved to reject material at any time before final acceptance if material and workmanship do not conform to Drawings and Specifications.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install items according to industry specifications and codes and reviewed shop drawings.

3.02 INSTALLING HANDRAILS & RAILINGS

- A. Install handrails and railings to comply with requirements of the Drawings, Specifications and any Manufacturers' written instructions and requirements.

3.03 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 05530

METAL GRATINGS AND COVER PLATES

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required to install metal gratings and floor cover plates along with embedded metal frames as shown on the Drawings or specified.

1.02 RELATED WORK

- A. Division 3 – Concrete
- B. Division 5 – Metals
- C. Division 9 – Coatings

1.03 REFERENCE STANDARDS

- A. International Code Council
 - 1. International Building Code (IBC)
- B. American Society of Civil Engineers (ASCE)
 - 1. ASCE-7: Minimum Design Loads for Buildings and Other Structures
- C. The Aluminum Association
 - 1. Aluminum Design Manual.
- D. American Institute of Steel Construction (AISC).
 - 1. Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings.
 - 2. Steel Construction Manual.
 - 3. Code of Standard Practice.
 - 4. Design Guide 27 – Structural Stainless Steel.
- E. American Welding Society (AWS):
 - 1. D1.1 Structural Welding Code – Steel
 - 2. D1.2 Structural Welding Code – Aluminum
 - 3. D1.6 Structural Welding Code – Stainless
- F. American Society for Testing and Materials (ASTM):
 - 1. ASTM A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 2. ASTM A240 – Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for pressure Vessels and General Applications.
 - 3. ASTM A572 - Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.

4. ASTM A1008 - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
 5. ASTM A1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
 6. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 7. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
- G. National Association of Architectural Metal Manufacturers (NAAMM)
1. ANSI/NAAMM MBG531 - Metal Bar Grating Manual.
 2. ANSI/NAAMM MBG532 - Heavy Duty Metal Bar Grating Manual.
 3. ANSI/NAAMM MBG533 - Welding Standards For Fabrication of Steel, Stainless Steel and Aluminum Bar Grating.
 4. NAAMM MBG534 - Metal Bar Grating Engineering Design Manual.

1.04 SUBMITTALS

- A. Shop Drawings
1. Submit shop drawings as specified in Division 1, General Provisions.
 2. Submit detailed shop drawings showing sizes of members, method of assembly, anchorage, and connection to other members for approval prior to fabrication.
- B. Submit Manufacturer's product data for gratings and cover plates including span and deflection tables and details of construction.
- C. Submit Manufacturer's installation instructions.
- D. Submit samples of gratings and cover plates, if requested by the Construction Manager.

1.05 COORDINATION

- A. The Work of this Section shall be completely coordinated with the Work of other Sections. Verify at the Site the dimensions and the Work of other trades adjoining items of Work in this Section before fabricating or installing the items specified.
- B. Furnish to the pertinent trades all items included under this Section that are to be built into the Work of other Sections.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect gratings and cover plates against scratching, splashes, mortar, paint and other damage during transportation, storage, installation, and until adjacent work by other trades is complete.

PART 2 PRODUCTS

2.01 GENERAL

- A. Provide products that conform to the following unless otherwise shown on the Drawings.

2.02 PERFORMANCE CRITERIA

- A. Grating:

- 1. Design Loads, choose whichever gives the greatest stresses:
 - a. Pedestrian Access Only
 - (i) Uniform Live Load: 250 psf
 - (ii) Concentrated Live Load: 3,000 lbs
 - (iii) Maximum Clear Span Deflection:
 - (a) $L/360$ or 1/4 inch, whichever is less, under uniform loading of 100 psf.
 - b. Vehicular Access
 - (i) Uniform Live Load: 250 psf
 - (ii) Concentrated Live Load: 16,000 lb wheel load with an impact factor of 1.33 over a 20 inch by 10 inch tire contact area.
 - (iii) Maximum Clear Span Deflection:
 - (a) $L/360$ or 1/4 inch, whichever is less, under uniform loading of 100 psf.
- 2. Bar Layout:
 - a. Bearing bars shall be 3/16 inches minimum spaced at a maximum of 1 3/16 inches on center.
 - b. Cross bar spacing shall not exceed 4 inches on center.

- B. Checkered Cover Plate:

- 1. Design Loads, choose whichever gives the greatest stresses:
 - a. Pedestrian Access Only
 - (i) Uniform Live Load: 250 psf
 - (ii) Concentrated Live Load: 3,000 lbs
 - (iii) Maximum Clear Span Deflection:
 - (a) $L/360$ or 1/4 inch, whichever is less, under uniform loading of 100 psf.
 - b. Vehicular Access
 - (i) Uniform Live Load: 300 psf
 - (ii) Concentrated Live Load: 16,000 lb wheel load with an impact factor of 1.33 over a 20 inch by 10 inch tire contact area.
 - (iii) Maximum Clear Span Deflection:
 - (a) $L/360$ or 1/4 inch, whichever is less, under uniform loading of 100 psf.

2.03 MATERIALS

A. Rectangular Bar Grating and Appurtenances

1. General Requirements

- a. Provide grating of the material, depths, and bearing bar thicknesses as shown on the Drawings and as specified. If not shown on the Drawings, provide grating that meets the performance criteria in 2.02.
- b. Grating shall be banded along edges and around openings two inches or greater in diameter/dimension with a bar of the same depth and thickness as the bearing bars. Bearing or cross bars shall be welded to the banding bar.
- c. Embedded grating support frames shall be of the same material as the grating, unless otherwise shown on the Drawings.
- d. Attach grating to supports using sturdy 16 gauge saddle type clips and fasteners, or approved equal.

2. Aluminum Grating

- a. Alloy 6061-T6 or 6063-T6 conforming to ASTM B221

B. Cover Plates

1. General Requirements

- a. Provide cover plates of the material, depths, and with stiffening members as detailed on the Drawings and as specified. If not detailed on the Drawings, provide cover plates that meet the performance criteria in 2.02.
- b. Cover plates shall be tread plate having a raised figure pattern on one surface to provide improved traction.

2. Steel Cover Plates

- a. Steel cover plates shall be galvanized ASTM A572, Grade 50 steel plate or ASTM A240 316L stainless steel plate (25 ksi) as called for in the Drawings.
- b. Frames and supports shall match the cover plate material.
- c. Fastening devices and hardware shall match the cover plate material.

3. Aluminum Cover Plates

- a. Alloy 6061-T6.
- b. Frames and supports shall be all aluminum construction.
- c. Fastening devices and hardware shall be Type 316 stainless steel.
- d. Mill Finish.

2.04 FABRICATION

- A. Provide work true to detail; with clean, straight, sharply defined profiles, and smooth surfaces of uniform color and texture free from defects impairing strength or durability.
- B. Field verify dimensions and support locations prior to fabrication.
- C. Provide connections and accessories of sufficient strength to safely withstand stresses and strains to which they will be subjected. Threaded connections shall be made so that the threads are concealed by fitting.

- D. Angle frames for grating and floor plates shall be mitered and welded at corners and with welded strap anchors or headed studs attached.
- E. Welded joints shall be rigid and continuously welded or spot welded as specified or shown. Dress the face of welds flush and smooth. Exposed joints shall be close fitting and located where least conspicuous.
- F. Welding of parts shall be in compliance with the latest edition of AWS D1.1 or AWS D1.2, as applicable. Welding only to be done where shown, specified, or permitted by the ENGINEER. Welding shall be done by welders certified to perform welding in accordance with the requirements of the AWS Code. Component parts of built-up members to be welded shall be adequately supported and clamped or held by other adequate means to hold the parts in proper relation for welding.
- G. Weld aluminum work on the unexposed side when possible in order to prevent pitting or discoloration.
- H. Grating sections shall be fabricated so that longitudinal and cross bars in adjacent sections shall be in line when erected. Grating shall be furnished in reasonable size pieces, avoiding patchwork, with due regard for neat overall appearance.

PART 3 EXECUTION

3.01 INSPECTION

- A. Verify that opening sizes and dimensional variations are acceptable for installation of grating or cover plates at the specified tolerances. Report any non-complying areas to the Construction manager prior to proceeding with installation.

3.02 INSTALLATION

- A. Install all items furnished except items to be embedded in concrete which shall be installed under Division 3. Install items to be attached to concrete or masonry after such work is completed and in compliance with the details shown.
- B. Field cutting of finished surfaces is not allowed unless specifically approved by the ENGINEER. When cutting is approved, use mechanical cutting tools; do not use flame cutting tools.
- C. Secure grating with fastening devices as specified to prevent movement, except where removable grating is called for on Drawings.
- D. Unless otherwise shown, cover plates shall be shop drilled using countersunk holes for bolting hardware. Supporting embedded framing shall be field drilled using the cover plate as a template.
- E. Where aluminum contacts a dissimilar metal, field-apply a heavy brush coat of zinc-chromate primer followed by two coats of aluminum metal and masonry paint to the dissimilar metal.

- F. Where aluminum contacts masonry or concrete, field-apply a heavy brush coat of zinc chromate primer to the masonry or concrete. For embedded items, coat the embed.
- G. Where aluminum contacts wood, field-apply two coats of aluminum metal and masonry paint to the wood.

3.03 FIELD QUALITY CONTROL

A. TOLERANCES

1. Maximum space between adjoining or abutting sections: ¼-inch.
2. Maximum variation from top surface plane of adjoining or abutting sections or structure: 1/8-inch.

3.04 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 05540

METAL LADDERS, PLATFORMS & STAIRS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This Section specifies metal ladders and stairs including related platforms and safety accessories. All items listed are not necessarily included in the project, see Drawings for specific project requirements.

1.02 RELATED WORK

- A. Division 3 – Concrete
- B. Division 5 – Metals
- C. Division 9 – Coatings

1.03 REFERENCE STANDARDS

- A. International Code Council
 - 1. International Building Code (IBC)
- B. American Society of Civil Engineers (ASCE)
 - 1. ASCE-7: Minimum Design Loads for Buildings and Other Structures
- C. The Aluminum Association
 - 1. Aluminum Design Manual.
- D. American Institute of Steel Construction (AISC).
 - 1. Steel Construction Manual.
 - 2. Design Guide 27 – Structural Stainless Steel.
- E. American Welding Society (AWS):
 - 1. D1.1 Structural Welding Code - Steel.
 - 2. D1.2 Structural Welding Code – Aluminum
 - 3. D1.3 Structural Welding Code – Sheet Steel
 - 4. D1.6 Structural Welding Code – Stainless Steel
- F. American Society for Testing and Materials (ASTM):
 - 1. ASTM A36 – Standard Specification for Carbon Structural Steel.
 - 2. ASTM A48 – Standard Specification for Gray Iron Castings.
 - 3. ASTM A53 – Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 4. ASTM A108 – Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
 - 5. ASTM A123 – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

6. ASTM A153 – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
7. ASTM A193 – Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
8. ASTM A240 – Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and General Applications.
9. ASTM A276 – Standard Specification for Stainless Steel Bars and Shapes.
10. ASTM A307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
11. ASTM A325 – Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
12. ASTM A490 – Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.
13. ASTM A500 – Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
14. ASTM A572 – Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
15. ASTM A653 – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
16. ASTM A780 – Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
17. ASTM A992 – Standard Specification for Structural Steel Shapes.
18. ASTM A1008 – Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
19. ASTM A1011 – Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
20. ASTM B26, Specification for Aluminum-Alloy Sand Castings.
21. ASTM B136, Standard Method for Measurement of Stain Resistance of Anodic Coatings on Aluminum.
22. ASTM B137, Standard Test Method for Measurement of Coating Mass Per Unit Area on Anodically Coated Aluminum.
23. ASTM B209 – Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
24. ASTM B210, Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes.
25. ASTM B221 – Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
26. ASTM B241, Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube.
27. ASTM B244, Standard Test Method for Measurement of Thickness of Anodic Coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments.

28. ASTM B247, Standard Specification for Aluminum and Aluminum-Alloy Die Forgings, Hand Forgings, and Rolled Ring Forgings.
29. ASTM B429, Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
30. ASTM F593 – Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

- G. The American Society of Safety Engineers (ASSE)
 1. ASSE A1264.1, Safety Requirements for Workplace Walking/Working Surfaces & Their Access; Workplace Floor, Wall & Roof Openings; Stairs & Guardrails Systems
- H. The Society for Protective Coatings (SSPC):
 1. SSPC Painting Manual, Volumes 1 & 2.
- I. United States Department of Labor:
 1. OSHA Regulations (Standards – 29 CFR); Part 1926 - Safety and Health Regulations for Construction.

1.04 SUBMITTALS

- A. Shop Drawings:
 1. Submit shop drawings as specified in Division 1, General Provisions.
 2. Submit detailed shop drawings showing sizes of members, method of assembly, anchorage, and connection to other members for approval prior to fabrication.
- B. If design and details for ladders, stairs, platforms or other systems and elements are not shown in the Drawings, provide a letter sealed by a Licensed Professional Engineer in the State which the project will be built stating that the proposed design and details have been designed and detailed under their supervision and meet all codes referenced herein and requirements herein.
- C. Certificates: Submit certified mill reports from the material supplier. Reports must provide heat or melt number mill analysis and test results for structural steel. If reports are not submitted or if the material cannot be positively identified and directly related to the reports, material quality tests will be required at no cost to the OWNER.

1.05 COORDINATION

- A. The Work herein shall be completely coordinated with the Work of other Sections. Verify at the Site the dimensions and the Work of other trades adjoining items of Work herein before fabricating or installing the items specified.
- B. Furnish to the pertinent trades all items included herein that are to be built into the Work of other Sections.

1.06 PRODUCT DELIVERY AND STORAGE

- A. Schedule material delivery so that items may be installed promptly after arrival.

- B. If materials must be stored, keep them off the ground and clean, free of dirt, mud, grease or oil. Store in such a manner to avoid member distortion. Protect steel and aluminum from corrosion and/or deterioration.

PART 2 PRODUCTS

2.01 GENERAL

- A. For metal fabrications exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

2.02 ALUMINUM

- A. Materials

1. Aluminum structural shapes, bars and plates:
 - a. Alloy 6061-T6.
2. Extruded aluminum pipe:
 - a. Alloy 6063-T6 or 6061-T6.
3. Aluminum Castings:
 - a. Alloy 535.

- B. Fabrication

1. Follow general fabrication requirements elsewhere in herein.
2. Fabricate aluminum shapes and plates as shown. Furnish welded and mitered angle frames and other fabrications complete with welded anchors attached. Furnish all miscellaneous aluminum shown but not otherwise detailed. Structural shapes and extruded items shall comply with the dimensions on the Drawings within the tolerances published by the Aluminum Association.
3. Weld aluminum work on the unexposed side when possible in order to prevent pitting or discoloration of exposed aluminum surfaces.

- C. Finishes

1. All exposed aluminum surfaces shall have anodized finish unless otherwise specified. Apply a coat of methacrylate lacquer to all aluminum before shipment.

2.03 FERROUS METALS

- A. Structural Steel:

1. All rolled structural shapes, plates and bars must meet the standards for ASTM A992 and ASTM A572, Grade 50 unless otherwise shown in the Drawings or called for in design.
2. Clip angles, stiffeners, plates and other detail items must conform to standards of the main member to which the items are attached unless noted otherwise.

- B. Steel Pipe

1. Conform to ASTM A53, Type E or S, Grade B, welded or seamless. No hydrostatic tests required.

- C. Structural Steel Tubing:
 - 1. Conform to ASTM A500, Grade B, with minimum yield strength of 46,000 psi. No hydrostatic tests required.
- D. Stainless Steel:
 - 1. Use the stainless steel grade indicated on the Drawings (304 or 316). Where the grade is not specified use AISI 316. Use a weldable (304L or 316L) grade of stainless steel for welded items.
 - 2. For all stainless steel, required minimum yield strength is as follows unless otherwise noted on the Drawings.
 - a. 304 or 316: 30,000 psi.
 - b. 304L or 316L: 25,000 psi.

2.04 FASTENERS:

- A. Provide ASTM F593, Type 316 fasteners for exterior use or when called for in the Drawings.
- B. Structural Steel Bolts, Nuts & Washers
 - 1. Bolts & Nuts:
 - a. Use high-strength bolts, conforming to ASTM A325 with hex nuts.
 - 2. Washers
 - a. Plain washers, use round, carbon steel, ASME B18.22.1.
 - b. Lock washers, use helical, spring type, carbon steel, ASME B18.22.1.

2.05 ALUMINUM LADDERS

- A. Performance Criteria
 - 1. Fixed ladders and side extensions shall meet the load requirements of ASCE-7, Section 4.5.4.
 - 2. Fixed ladders and accessories shall be certified as meeting current requirements of IBC, ASCE-7 and OSHA.
- B. Materials:
 - 1. Side Rails/Safety Cages, Rail Extension, and Platform:
 - a. Aluminum plates, alloy 6061-T6
 - b. Aluminum extrusions, alloy 6063-T5.
 - 2. Rungs:
 - a. Knurled or serrated aluminum bars, 1.25-inch in square section, alloy 6061-T6.
 - b. Weld size and filler material shall meet required design strength.
 - 3. Rail Extension:
 - a. Minimum 3'-6" above the landing and shall be fitted with deeply serrated, square, tubular grab rails.
 - 4. Safety cage:
 - a. Provide safety cage on all ladders over 20 feet unless otherwise noted in the Drawings.

- 5. Landing Platform:
 - a. Provide at 30 foot intervals above the bottom of the ladder, complete with 1-1/2 inch or greater diameter tubular aluminum guard rails and decks of serrated aluminum treads.
- 6. Wall/Floor Support Brackets.:
 - a. Aluminum plates, alloy 6061-T6.
 - b. 316 SS fasteners/rigid attack/locking.
- C. Acceptable Manufacturers:
 - 1. O'Keefe's.
 - 2. Alaco.
- D. Ladder safety post extensions
 - 1. Each fixed ladder occurring below a hatch door shall be provided with an attached telescoping safety post extension of aluminum construction. Unit shall be completely assembled with stainless steel fasteners and brackets for securing to the ladder rungs provided by the Manufacturer.
 - 2. Acceptable Manufacturers: Bilco - Ladder Up Safety Post, Model 2; or equal.

2.06 STEEL LADDERS

- A. Performance Criteria
 - 1. Fixed ladders and side extensions shall meet the load requirements of ASCE-7, Section 4.5.4.
 - 2. Fixed ladders and accessories shall be certified as meeting current requirements of IBC, ASCE-7 and OSHA.
- B. Materials:
 - 1. General:
 - a. Provide stainless steel, coated steel or galvanized steel as called for in the Drawings.
 - 2. Fasteners:
 - a. Provide fasteners of the same material type as the ladder elements.
 - b. Provide stainless steel anchor bolts unless otherwise specified in the Drawings.
- C. Acceptable Manufacturers:
 - 1. O'Keefe's.
 - 2. Alaco.
- D. Ladder safety post extensions
 - 1. Each fixed ladder occurring below a hatch door shall be provided with an attached telescoping safety post extension of aluminum construction. Unit shall be completely assembled with stainless steel fasteners and brackets for securing to the ladder rungs provided by the Manufacturer.
 - 2. Acceptable Manufacturers: Bilco - Ladder Up Safety Post, Model 2; or equal.

2.07 STAIRS AND PLATFORMS

A. General

1. Provide stairs and platforms of the material designated where shown in the Drawings. If stair or platform details are not shown, provide a system meeting the performance criteria herein.

B. Performance Criteria:

1. Design Loads, choose whichever gives the greatest stresses:
 - a. Uniform Live Load: 125 psf
 - b. Concentrated Live Load: 1,500 lbs
 - c. Maximum Clear Span Deflection:
 - (i) $L/360$ or $1/4$ inch, whichever is less, under uniform loading of 100 psf.

C. Geometric Requirements:

1. Meet all geometric requirements for stair tread sizes, rise/run, landing locations and sizes, clearances, etc. of the reference codes and standards listed in herein.

2.08 GALVANIZING:

- A. Hot-dipped zinc coat structural items specifically designated as galvanized after fabrication. Conform to the applicable standard, ASTM A123 or ASTM A153.

- B. Use repair coating which conforms to ASTM A780. Acceptable products include:

1. Carboline Carbo Zinc No. 11.
2. Galv-Weld Products Galv-Weld Alloy.
3. Koppers Organic Zinc coating.

- C. Unless otherwise noted all structural steel shall be galvanized.

2.09 FABRICATION

- A. Fabricate according to industry reference standards, codes, and these specifications unless directed or shown otherwise.

- B. Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

- C. Shear and punch metals cleanly and accurately. Remove burrs.

- D. Ease exposed edges to a radius of approximately $1/32$ -inch (1 mm), unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

- E. Weld corners and seams continuously to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.
 3. Remove welding flux immediately.
 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- F. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
 - G. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
 - H. Fabricate joints that will be exposed to weather in a manner to exclude water, or provide weep holes where water may accumulate.
 - I. Allow for thermal movement resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening up of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
 - J. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges.
 - K. Remove sharp or rough areas on exposed traffic surfaces.
 - L. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous.
- 2.10 WELDING
- A. Perform welding in accord with the AWS reference standard. Use procedures such as preheat or interpass temperature as recommended by AWS standards.
 - B. All shop and field welding must be performed by qualified welders who hold current welding certificates.
 - C. Surfaces to be welded must be free of loose scale, slag, rust, grease, paint and other foreign material. Mill scale which withstands vigorous wire brushing may remain.
 - D. Joint surfaces must be free of fins and tears caused by shearing. Wherever practicable, prepare edges by gas cutting using a mechanically guided torch.
 - E. Electrodes:
 1. For structural steel, use AWS Low Hydrogen, Electrode E70XX Series suitable for the welding process used.

2. For stainless steel, use 70 ksi minimum tensile strength filler material suitable for base metals and welding process in accordance with AWS specifications.
 3. For aluminum, use filler alloy 5356 in accordance with AWS specifications.
 4. Protect electrodes from exposure to moisture and coating.
- F. If shop welding is done by automatic, submerged arc process, verify that physical properties of deposited weld metal will be similar to properties of the base metal.
- G. No welding shall be done when the temperature of the base metal is below 32°F.
- H. The cover bead or finish pass must have a smooth, uniform surface with reinforcement of 1/16 to 1/8 inch. Surface voids, cracks in finish weldments, or undercutting of base metal at the fusion line is not acceptable.

2.11 SURFACE PREPARATION AND PAINTING

- A. All surfaces shall be prepared and finished in accordance with Division 9 requirements unless otherwise noted in the Drawings. Structural steel shall be shop primed. Stainless steel shall not be coated unless otherwise specified in the Drawings or elsewhere in the Specifications.
- B. Galvanize structural steel items specifically shown or specified as galvanized in the Drawings. Members that are warped during the galvanizing process will be rejected.

2.12 INSPECTION AND TESTING

- A. Mill or shop inspection and non-destructive testing (in addition to field inspection and non-destructive testing) may be done by the OWNER.
- B. Inspection in mill, shop, or field in no way relieves the CONTRACTOR from their responsibility to furnish satisfactory materials. Right is reserved to reject material at any time before final acceptance if material and workmanship do not conform to Drawings and Specifications.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install items according to industry specifications and codes and reviewed shop drawings.
- B. Fastening to In-Place Construction:
1. Provide anchorage devices and fasteners where necessary for securing metal fabrications to in-place construction. Include threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts and other connectors.
- C. Cutting, Fitting, and Placement:
1. Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.

- D. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- E. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- F. Field Welding: Comply with the following requirements:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

3.02 INSTALLING LADDERS

- A. Install ladders to comply with requirements of the Drawings, Specifications and any Manufacturers' written instructions and requirements.

3.03 ADJUSTING AND CLEANING

- A. Touchup Painting:
 - 1. Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop painting to comply with SSPC-PA1 for touching up shop-painted surfaces. Apply by brush or spray to provide a minimum 2.0-mil dry film thickness.
 - 2. Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Division 9.
- B. Repair of Galvanized Surfaces:
 - 1. Thoroughly clean field welds, bolted connections, abrasions, abraded areas and galvanized surfaces damaged from welding, handling, or installation shall be repaired immediately after installation with galvanizing repair material. Apply matching galvanized repair coat as specified herein. Galvanizing repair shall be performed and completed before concrete is placed. Any member requiring repair of more than 2 percent of the surface area shall be rejected.

3.04 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 06500

FIBERGLASS REINFORCED PLASTICS & FABRICATIONS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required to fabricate and install FRP gratings, stairs, handrails, ladders and other structural fabrications as shown on the Drawings or as specified.

1.02 RELATED WORK

- A. Division 3 – Concrete
- B. Division 5 – Metals
- C. Division 6 – Woods and Plastics

1.03 REFERENCE STANDARDS

- A. International Code Council
 - 1. International Building Code (IBC)
- B. American Society of Civil Engineers (ASCE)
 - 1. ASCE-7: Minimum Design Loads for Buildings and Other Structures
- C. American Composites Manufacturers Association (ACMA)
 - 1. FRP Composite Fiberglass Grating Manual
- D. United States Department of Labor:
 - 1. OSHA Regulations (Standards – 29 CFR); Part 1926 – Safety and Health Regulations for Construction.
- E. American Society for Testing and Materials (ASTM):
 - 1. ASTM D349 – Standard Test Methods for Laminated Round Rods Used for Electrical Insulation.
 - 2. ASTM D495 – Standard Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
 - 3. ASTM D635 – Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
 - 4. ASTM D638 – Standard Test Method for Tensile Properties of Plastics.
 - 5. ASTM D696 – Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between –30°C and 30°C with a Vitreous Silica Dilatometer.
 - 6. ASTM D790 – Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
 - 7. ASTM D792 – Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
 - 8. ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials.
 - 9. ASTM F593 – Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

1.04 SUBMITTALS

- A. Shop Drawings:
 - 1. Submit shop drawings as specified in Division 1 – General Requirements and as required by the Contract Documents.
 - 2. Submit detailed shop drawings showing sizes of members, method of assembly, anchorage, and connection to other members for approval prior to fabrication.
- B. Product Data:
 - 1. Submit all Manufacturer's product data for gratings, including span and deflection tables and details of construction.
 - 2. Submit all Manufacturer's product data for other FRP shapes and fabrications, including all dimensions and material properties required to review the product versus the requirements of this specification.
 - 3. Submit certified test data based on tests of actual production samples which demonstrate that the products conforms to the stress and deflection requirements specified herein.
- C. Submit documentation, in the form of a letter and/or calculations, which confirms that the performance criteria herein is met by the FRP products and fabrications provided. The documentation shall be signed and sealed by a Professional Engineer licensed in the State of Texas.
- D. Submit Manufacturer's installation instructions.
- E. Submit samples of gratings and other products, if requested by the OWNER's Representative.

1.05 COORDINATION

- A. The Work herein shall be completely coordinated with the Work of other Sections. Verify at the Site the dimensions and the Work of other trades adjoining items of Work herein before fabricating or installing the items specified.
- B. Furnish to the pertinent trades all items included herein that are to be built into the Work of other Sections.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect gratings and other FRP products against scratching, splashes, mortar, paint and other damage during transportation, storage, installation, and until adjacent work by other trades is complete.

1.07 QUALITY ASSURANCE

- A. All FRP products and fabrications shall be supplied by an experienced firm who has continually engaged in the manufacture and/or fabrication of the FRP products used on the project for a minimum of five years.

PART 2 PRODUCTS

2.01 GENERAL

- A. All FRP items herein shall be composed of fiberglass reinforcements and resins in qualities, quantities, properties, arrangements and dimensions as necessary to meet the design requirements and dimensions as specified in the Drawings and Specifications.
- B. Fiberglass reinforcement shall be a combination of continuous roving, continuous strand mats and/or surfacing veils in sufficient quantities as required by the application or to meet physical properties.
- C. Resin shall be vinyl ester for all systems integrally resistant, without applied coatings, to ultra violet radiation, and to all chemicals present in each of the respected facilities identified in the Drawings.
- D. All finished surfaces shall be smooth, resin rich, free of voids and without dry spots, cracks, crazes or unreinforced areas. All glass fibers shall be well covered with resin to protect against their exposure due to wear or weathering.
- E. All FRP shall have a tested flame spread rating of 25 or less in accordance with ASTM E84.

2.02 PERFORMANCE CRITERIA

- A. FRP Grating & Platforms:
 - 1. Design Loads:
 - a. Pedestrian Access Only
 - (i) Uniform Live Load: 125 psf
 - (ii) Concentrated Live Load: 1,500 lbs
 - b. Vehicular Access
 - (i) Uniform Live Load: 250 psf
 - (ii) Concentrated Live Load: 16,000 lb wheel load with an impact factor of 1.33 over a 20 inch by 10 inch tire contact area.
 - 2. Maximum Clear Span Deflection:
 - a. $L/360$ or 1/4 inch, whichever is less, under uniform loading of 100 psf.
 - 3. Bar Layout:
 - a. Bearing bars shall be 3/16 inches minimum spaced at a maximum of 1 3/16 inches on center.
 - b. Cross bar spacing shall not exceed 4 inches on center.
- B. FRP Structural Members:
 - 1. Design Loads:
 - a. Meet all applicable design loads and geometric requirements of the most current version of IBC, ASCE-7 and OHSA.
 - b. If structural members support grating or platforms, meet the loading requirements for FRP Grating herein.
 - 2. Maximum Member Deflection:
 - a. $L/180$ under the controlling load combination.

- C. FRP Handrailing
 - 1. Design Loads & Geometry:
 - a. Meet all applicable design loads, allowable deflections and geometric requirements of the most current version of IBC, ASCE-7 and OSHA.
- D. FRP Stair Treads:
 - 1. Design Loads & Geometry:
- E. Meet all applicable design loads and geometric requirements of the most current version of IBC, ASCE-7 and OSHA.
- F. FRP Ladders
 - 1. Design Loads & Geometry:
 - a. Meet all applicable design loads and geometric requirements of the most current version of IBC, ASCE-7 and OSHA.

2.03 PRODUCTS & MATERIALS

- A. FRP Grating
 - 1. Molded fiberglass using a vinyl ester resin with chemical formulations suitable for chemical exposure to all chemicals present in each of the respected facilities identified in the Drawings.
 - 2. Tested burn time of less than 30 seconds and an extent of burn rate less than or equal to 10 mm per ASTM D635.
 - 3. Color: Yellow
 - 4. Provide grating that meets the performance criteria in 2.02.
 - 5. Provide structural FRP angle frames, structural support shapes, and grit impregnated plate where required and appurtenances as shown.
 - 6. Provide FRP angle frames continuous around the grated openings and trenches in order to present an even and flat support for the grating except as otherwise shown. The angles and anchors shall be as per the Manufacturer.
 - 7. Top surfaces shall have grit surface for skid resistance.
 - 8. Coordinate the layout of grating panels with work of other Sections to provide openings for approved mechanical equipment, operators, gates and other items which require penetrations or openings in the grating. Grating panels shall be further subdivided and supported to provide maximum panel weight of 110 lbs.
 - 9. Attach grating to supports using 316 stainless steel grating clips and fasteners.
- B. FRP Handrailing
 - 1. System shall be composed of FRP tubes; solid FRP connector plugs snugly fitting the inside dimensions of tubes; solid FRP connector rods; and flattened corrugated, 4 in high, FRP kickplates with 0.5 in deep corrugations and 316 stainless steel drive rivets for fastening to posts. Provide FRP sleeves for removable connections to concrete and provide FRP baseplate assemblies with 316 stainless steel fasteners for wall connections and for slab connections where shown. Provide approved epoxy cement for all tube, plug and rod connections and epoxy grout for post connections set in concrete.
 - 2. Fabricate with continuous posts and top rail, with intermediate rails cut between posts. Miter corners and direction changes neatly. Provide for rail expansion as

required with internal plugs cemented one side and square, resin sealed, tube ends. Provide for kickplate expansion as detailed.

3. Tested burn time of less than 30 seconds and an extent of burn rate less than or equal to 10 mm per ASTM D635.
4. Color: Yellow.
5. All required fasteners shall be 316 stainless steel.

C. FRP Stair Treads

1. Molded fiberglass using a vinyl ester resin with chemical formulations suitable for chemical exposure to all chemicals present in each of the respected facilities identified in the Drawings.
2. Tested burn time of less than 30 seconds and an extent of burn rate less than or equal to 10 mm per ASTM D635.
3. Top surfaces shall have grit surface for skid resistance and 1 3/4" integral bull nosing.
4. Color: Yellow
5. All required fasteners shall be 316 stainless steel.

D. FRP Structural Shapes

1. Structural shapes shall be molded fiberglass using a vinyl ester resin with chemical formulations suitable for chemical exposure to all chemicals present in each of the respected facilities identified in the Drawings.
2. Shapes shall be designed by a Professional Engineer licensed in the State where the project is located to withstand all design loads required in the Specifications and the Drawings.
3. Utilize 316 stainless steel fasteners, bolts and washers.
4. Tested burn time of less than 30 seconds and an extent of burn rate less than or equal to 10 mm per ASTM D635.
5. Color: Yellow.

E. FRP Ladders

1. All ladder components shall be flame retardant per ASTM E84, Class 1.
2. Ladder rungs shall be 1 inch solid round with slip-resistant quartz epoxy grit surface. Rungs shall penetrate inside wall of ladder rail tube and be countersunk into outside wall of ladder rail tube. Fully bond connection with epoxy to prevent rung rotation.
3. Ladder rails, base mount brackets, stand-off brackets and cages shall be FRP.
4. Utilize 316 stainless steel fasteners, bolts and washers.
5. Tested burn time of less than 30 seconds and an extent of burn rate less than or equal to 10 mm per ASTM D635.
6. Color: Yellow.

2.04 FABRICATION

- A. Provide work true to detail; with clean, straight, sharply defined profiles, and smooth surfaces of uniform color and texture free from defects impairing strength or durability.
- B. Field verify dimensions and support locations prior to fabrication.

- C. Grating sections shall be fabricated so that longitudinal and cross bars in adjacent sections shall be in line when erected. Grating shall be furnished in reasonable size pieces, avoiding patchwork, with due regard for neat overall appearance.

PART 3 EXECUTION

3.01 INSPECTION

- A. Verify that opening sizes and dimensional variations are acceptable for installation of grating at the specified tolerances. Report any non-complying areas to the Construction manager prior to proceeding with installation.

3.02 INSTALLATION

- A. Install all items furnished except items to be embedded in concrete which shall be installed under Division 3 – Concrete. Install items to be attached to concrete or masonry after such work is completed and in compliance with the details shown.

3.03 FIELD QUALITY CONTROL

A. TOLERANCES

1. Maximum space between adjoining or abutting sections: ¼-inch.
2. Maximum variation from top surface plane of adjoining or abutting sections or structure: 1/8-inch.

3.04 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 07115
BITUMINOUS DAMPPROOFING

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Section Includes:
 - 1. Cold-applied, cut-back-asphalt dampproofing.
 - 2. Cold-applied, emulsified-asphalt dampproofing.
- B. RELATED requirements
 - 1. Section 04200 "Unit Masonry".

1.02 RELATED WORK

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUBMITTALS

- A. Product Data: For each type of product.

1.04 REFERENCE STANDARDS (NOT USED)

1.05 QUALITY ASSURANCE (NOT USED)

1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)

1.07 DELIVERY, HANDLING AND STORAGE (NOT USED)

1.08 MAINTENANCE/SPARE PARTS (NOT USED)

1.09 WARRANTY/EXTENDED WARRANTY (NOT USED)

1.10 FIELD CONDITIONS

- A. Weather Limitations: Proceed with application only when existing and forecasted weather conditions permit dampproofing to be performed according to manufacturers' written instructions.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Source Limitations: Obtain primary dampproofing materials and primers from single source from single manufacturer. Provide protection course and auxiliary materials recommended in writing by manufacturer of primary materials.

2.02 PERFORMANCE REQUIREMENTS

- A. VOC Content: Products shall comply with VOC content limits of authorities having jurisdiction unless otherwise indicated.

2.03 COLD-APPLIED, EMULSIFIED-ASPHALT DAMPPROOFING

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. BASF Corporation, Master Seal 615.
- B. Fibered Brush and Spray Coats: ASTM D1227, Type II, Class 1.

2.04 AUXILIARY MATERIALS

- A. Furnish auxiliary materials recommended in writing by dampproofing manufacturer for intended use and compatible with bituminous dampproofing.
- B. Patching Compound: Asbestos-free fibered mastic of type recommended in writing by dampproofing manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for surface smoothness, maximum surface moisture content, and other conditions affecting performance of the Work.
- B. Proceed with application only after substrate construction and penetrating work have been completed and unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Clean, prepare, and treat substrates according to manufacturer's written instructions. Provide clean, dust-free, and dry substrates for dampproofing application.
- B. Mask or otherwise protect adjoining exposed surfaces from being stained, spotted, or coated with dampproofing. Prevent dampproofing materials from entering and clogging weep holes and drains.
- C. Clean substrates of projections and substances detrimental to dampproofing work; fill voids, seal joints, and remove bond breakers if any.
- D. Apply patching compound to patch and fill tie holes, honeycombs, reveals, and other imperfections.

3.03 APPLICATION, GENERAL

- A. Comply with manufacturer's written instructions for dampproofing application, cure time between coats, and drying time before backfilling unless otherwise indicated.

1. Apply dampproofing to provide continuous plane of protection.
 2. Apply additional coats if recommended in writing by manufacturer or to achieve a smooth surface and uninterrupted coverage.
- B. Where dampproofing exterior face of inner wythe of exterior masonry cavity walls, lap dampproofing at least 1/4 inch onto flashing, masonry reinforcement, veneer ties, and other items that penetrate inner wythe.
1. Extend dampproofing over outer face of structural members and concrete slabs that interrupt inner wythe.
 2. Lap dampproofing at least 1/4 inch onto shelf angles supporting veneer.
- 3.04 COLD-APPLIED, EMULSIFIED-ASPHALT DAMPPROOFING
- A. Exterior Face of Inner Wythe of Cavity Walls: Apply primer and one brush or spray coat at not less than 1 gal./100 sq. ft. (0.4 L/sq. m).
- 3.05 PROTECTION COURSE INSTALLATION
- A. Install protection course over completed-and-cured dampproofing. Comply with dampproofing-material and protection-course manufacturers' written instructions for attaching protection course.
1. Support protection course over cured coating with spot application of adhesive type recommended in writing by protection-board manufacturer.
 2. Install protection course within 24 hours of dampproofing installation (while coating is tacky) to ensure adhesion.
- 3.06 PROTECTION
- A. Protect installed insulation drainage panels from damage due to UV light, harmful weather exposures, physical abuse, and other causes. Provide temporary coverings where panels are subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.
- B. Correct dampproofing that does not comply with requirements; repair substrates, and reapply dampproofing.
- 3.07 MEASUREMENT AND PAYMENT
- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 07620

SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes sheet metal flashing and trim in the following categories:
 - 1. Exposed trim.
 - 2. Metal flashing.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Section 04200 "Unit Masonry" for through-wall flashing and other integral masonry flashings specified as part of masonry work.
 - 2. Section 07920 "Joint Sealants" for elastomeric sealants.

1.03 PERFORMANCE REQUIREMENTS

- A. General: Install sheet metal flashing and trim to withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failing.

1.04 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product Data including manufacturer's material and finish data, installation instructions, and general recommendations for each specified flashing material and fabricated product.
- C. Samples of sheet metal flashing, trim, and accessory items, in the specified finish.
- D. Qualification data for firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experience Installer who has completed sheet metal flashing and trim work similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

1.06 PROJECT CONDITIONS

- A. Coordinate Work of this Section with interfacing and adjoining Work for proper sequencing of each installation. Ensure best possible weather resistance, durability of Work, and protection of materials and finishes.

PART 2 PRODUCTS

2.01 METALS

- A. Galvanized Steel Sheet: ASTM A 526, G 90, commercial quality, or ASTM A 527, G 90, lock-forming quality, hot-dip galvanized steel sheet with 0.20 percent copper, mill phosphatized where indicated for painting; not less than 0.0396 inch thick, unless otherwise indicated.
- B. Coil-Coated Galvanized Steel Sheet: Zinc-coated, commercial-quality steel sheet conforming to ASTM A 755, G 90 coating designation, coil coated with high-performance fluoropolymer coating as specified in "Coil-Coated Galvanized Steel Sheet Finish" Article; not less than 0.0336 inch thick, unless otherwise indicated. Provide prefinished material for exposed flashing and trim.
- C. Lead Sheet: ASTM B 749, Type L51121, copper-bearing lead sheet, with a minimum thickness of 0.0625 inch except not less than 0.0937 inch thick for applications where burning (welding) is involved.

2.02 MISCELLANEOUS MATERIALS AND ACCESSORIES

- A. Burning Rod for Lead: Same composition as lead sheet.
- B. Solder: ASTM B 32, Grade Sn50, used with rosin flux.
- C. Fasteners: Same metal as sheet metal flashing or other noncorrosive metal as recommended by sheet metal manufacturer. Match finish of exposed heads with material being fastened.
- D. Asphalt Mastic: SSPC-Paint 12, solvent-type asphalt mastic, nominally free of sulfur and containing no asbestos fibers, compounded for 15-mil dry film thickness per coat.
- E. Mastic Sealant: Polyisobutylene; non-hardening, non-skinning, nondrying, non-migrating sealant.
- F. Elastomeric Sealant: Generic type recommended by sheet metal manufacturer and fabricator of components being sealed and complying with requirements for joint sealants as specified in Division 7, Section 07920 "Joint Sealants."
- G. Epoxy Seam Sealer: 2-part, noncorrosive, aluminum seam-cementing compound, recommended by aluminum manufacturer for exterior and interior nonmoving joints, including riveted joints.
- H. Adhesives: Type recommended by flashing sheet metal manufacturer for waterproof and weather-resistant seaming and adhesive application of flashing sheet metal.

- I. Paper Slip Sheet: 5-lb/square (0.244 kg/sq. m) red rosin, sized building paper conforming to FS UU-B-790, Type I, Style 1b.
- J. Polyethylene Underlayment: ASTM D 4397, minimum 6-mil thick black polyethylene film, resistant to decay when tested according to ASTM E 154.
- K. Metal Accessories: Provide sheet metal clips, straps, anchoring devices, and similar accessory units as required for installation of Work, matching or compatible with material being installed; noncorrosive; size and thickness required for performance.
- L. Roofing Cement: ASTM D 4586, Type I, asbestos free, asphalt based.

2.03 FABRICATION, GENERAL

- A. Sheet Metal Fabrication Standard: Fabricate sheet metal flashing and trim to comply with recommendations of SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of the item indicated.
- B. Comply with details shown to fabricate sheet metal flashing and trim that fit substrates and result in waterproof and weather-resistant performance once installed. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.
- C. Form exposed sheet metal Work that is without excessive oil canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems.
- D. Seams: Fabricate nonmoving seams in sheet metal with flat-lock seams. Tin edges to be seamed, form seams, and solder. Do not join sheet metal with exposed pop-rivets.
- E. Expansion Provisions: Space movement joints at maximum of 10 feet (3 m) with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions in Work cannot be used or would not be sufficiently weatherproof and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with mastic sealant (concealed within joints).
- F. Sealed Joints: Form non-expansion, but movable, joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.
- G. Separate metal from non-compatible metal or corrosive substrates by coating concealed surfaces at locations of contact with asphalt mastic or other permanent separation as recommended by manufacturer.
- H. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of sheet metal exposed to public view.
- I. Fabricate cleats and attachment devices from same material as sheet metal component being anchored or from compatible, noncorrosive metal recommended by sheet metal manufacturer.
 - 1. Size: As recommended by SMACNA manual or sheet metal manufacturer for application but never less than thickness of metal being secured.

2.04 SHEET METAL FABRICATIONS

- A. General: Fabricate sheet metal items in thickness or weight needed to comply with performance requirements and as detailed.

2.05 COIL-COATED GALVANIZED STEEL SHEET FINISH

- A. High-Performance Organic Coating Finish: Apply the following system by coil-coating process on galvanized steel sheet as recommended by coating manufacturers and applicator.
 - 1. Fluoropolymer 2-Coat Coating System: Manufacturer's standard 2-coat, thermocured system composed of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 605.2.
 - a. Color and Gloss: As selected by Architect from manufacturer's full range of choices.
 - b. Resin Manufacturers: Subject to compliance with requirements, provide fluoropolymer coating systems containing resins produced by one of the following manufacturers:
 - (i) Ausimont USA, Inc. (Hylar 5000)
 - (ii) Elf Atochem North America, Inc. (Kynar 500)
 - 2. Coil-Coated Steel Sheet Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
 - a. Atas Aluminum Corporation.
 - b. MM Systems Corporation.
 - c. Vincent Metals.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions under which sheet metal flashing and trim are to be installed and verify that Work may properly commence. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. General: Unless otherwise indicated, install sheet metal flashing and trim to comply with performance requirements, manufacturer's installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Anchor units of Work securely in place by methods indicated, providing for thermal expansion of metal units; conceal fasteners where possible, and set units true to line and level as indicated. Install Work with laps, joints, and seams that will be permanently watertight and weatherproof.
- B. Install exposed sheet metal Work that is without excessive oil canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in

waterproof and weather-resistant performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.

- C. Expansion Provisions: Provide for thermal expansion of exposed sheet metal Work. Space movement joints at maximum of 10 feet (3 m) with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions in Work cannot be used or would not be sufficiently weatherproof and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with mastic sealant (concealed within joints).
- D. Soldered Joints: Clean surfaces to be soldered, removing oils and foreign matter. Pre-tin edges of sheets to be soldered to a width of 1-1/2 inches, except where pre-tinned surface would show in finished Work.
 - 1. Pre-tinning is not required for Lead.
 - 2. Do not use torches for soldering. Heat surfaces to receive solder and flow solder into joint. Fill joint completely. Completely remove flux and spatter from exposed surfaces.
- E. Sealed Joints: Form non-expansion, but movable, joints in metal to accommodate elastomeric sealant to comply with SMACNA standards. Fill joint with sealant and form metal to completely conceal sealant.
 - 1. Use joint adhesive for nonmoving joints specified not to be soldered.
- F. Seams: Fabricate nonmoving seams in sheet metal with flat-lock seams. Tin edges to be seamed, form seams, and solder.
- G. Separations: Separate metal from non-compatible metal or corrosive substrates by coating concealed surfaces, at locations of contact, with asphalt mastic or other permanent separation as recommended by manufacturer.
 - 1. Underlayment: Where installing stainless steel or aluminum directly on cementitious or wood substrates, install a slip sheet of red-rosin paper and a course of polyethylene underlayment.
 - 2. Bed flanges of Work in a thick coat of roofing cement where required for waterproof performance.
- H. Roof-Penetration Flashing: Coordinate roof-penetration flashing installation with roofing and installation of items penetrating roof. Install flashing as follows:
 - 1. Turn lead flashing down inside vent piping, being careful not to block vent piping with flashing.
 - 2. Seal and clamp flashing to pipes penetrating roof, other than lead flashing on vent piping.

3.03 CLEANING AND PROTECTION

- A. Clean exposed metal surfaces, removing substances that might cause corrosion of metal or deterioration of finishes.

- B. Provide final protection and maintain conditions that ensure sheet metal flashing and trim Work during construction is without damage or deterioration other than natural weathering at the time of Substantial Completion.

3.04 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 07920

JOINT SEALANTS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes sealants for the following applications, including those specified by reference to this Section:
 - 1. Exterior joints in the following vertical surfaces and non-traffic horizontal surfaces:
 - a. Joints in exterior masonry.
 - b. Perimeter joints between material listed above and frames of doors and windows.
 - c. Other joints as indicated.
 - 2. Interior joints in the following vertical surfaces and horizontal non-traffic surfaces:
 - a. Perimeter joints of exterior openings where indicated.
 - b. Perimeter joints between interior wall surfaces and frames of interior doors.
 - c. Joints between plumbing fixtures and adjoining walls, floors, and counters.
 - d. Other joints as indicated.

1.03 PERFORMANCE REQUIREMENTS

- A. Provide elastomeric joint sealants that establish and maintain watertight and airtight continuous joint seals without staining or deteriorating joint substrates.

1.04 SUBMITTALS

- A. Product Data: For each joint-sealant product indicated.
- B. Samples for Initial Selection: Manufacturer's color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.
- C. Product Certificates: Signed by manufacturers of joint sealants certifying that products furnished comply with requirements and are suitable for the use indicated.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who has specialized in installing joint sealants similar in material, design, and extent to those indicated for this Project and whose work has resulted in joint-sealant installations with a record of successful in-service performance.
- B. Source Limitations: Obtain each type of joint sealant through one source from a single manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to Project site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration date, pot life, curing time, and mixing instructions for multicomponent materials.
- B. Store and handle materials in compliance with manufacturer's written instructions to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

1.07 PROJECT CONDITIONS

- A. Environmental Limitations: Do not proceed with installation of joint sealants under the following conditions:
 - 1. When ambient and substrate temperature conditions are outside limits permitted by joint sealant manufacturer.
 - 2. When joint substrates are wet.
- B. Joint-Width Conditions: Do not proceed with installation of joint sealants where joint widths are less than those allowed by joint sealant manufacturer for applications indicated.
- C. Joint-Substrate Conditions: Do not proceed with installation of joint sealants until contaminants capable of interfering with adhesion are removed from joint substrates.

PART 2 PRODUCTS

2.01 PRODUCTS AND MANUFACTURERS

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the products specified in the sealant schedules at the end of Part 3.

2.02 MATERIALS, GENERAL

- A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.
- B. Colors of Exposed Joint Sealants: As selected by Architect from manufacturer's full range for this characteristic.

2.03 ELASTOMERIC JOINT SEALANTS

- A. Elastomeric Sealant Standard: Comply with ASTM C 920 and other requirements indicated for each liquid-applied chemically curing sealant in the Elastomeric Joint-Sealant Schedule at the end of Part 3, including those referencing ASTM C 920 classifications for type, grade, class, and uses.

- B. Stain-Test-Response Characteristics: Where elastomeric sealants are specified in the Elastomeric Joint-Sealant Schedule to be non-staining to porous substrates, provide products that have undergone testing according to ASTM C 1248 and have not stained porous joint substrates indicated for Project.

2.04 LATEX JOINT SEALANTS

- A. Latex Sealant Standard: Comply with ASTM C 834 for each product of this description indicated in the Latex Joint-Sealant Schedule at the end of Part 3.

2.05 ACOUSTICAL JOINT SEALANTS

- A. Acoustical Sealant for Exposed and Concealed Joints: For each product of this description indicated in the Acoustical Joint-Sealant Schedule at the end of Part 3, provide manufacturer's standard non-sag, paintable, non-staining latex sealant complying with ASTM C 834 and the following:

1. Product effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.

2.06 JOINT-SEALANT BACKING

- A. A.General: Provide sealant backings of material and type that are non-staining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
- B. Cylindrical Sealant Backings: ASTM C 1330, of type indicated below and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance:
 1. Type C: Closed-cell material with a surface skin.
- C. Elastomeric Tubing Sealant Backings: Neoprene, butyl, EPDM, or silicone tubing complying with ASTM D 1056, nonabsorbent to water and gas, and capable of remaining resilient at temperatures down to minus 26 deg F (minus 32 deg C). Provide products with low compression set and of size and shape to provide a secondary seal, to control sealant depth, and otherwise contribute to optimum sealant performance.
- D. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint where such adhesion would result in sealant failure. Provide self-adhesive tape where applicable.

2.07 MISCELLANEOUS MATERIALS

- A. Primer: Material recommended by joint sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants with joint substrates.
- C. Masking Tape: Non-staining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. A.Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint sealant manufacturer's written instructions and the following requirements:
 - 1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
 - 2. Clean porous joint substrate surfaces by brushing, grinding, blast cleaning, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining from above cleaning operations by vacuuming or blowing out joints with oil-free compressed air. Porous joint surfaces include the following:
 - a. Concrete.
 - b. Masonry.
 - 3. Remove laitance and form-release agents from concrete.
 - 4. Clean nonporous surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants.
 - a. Metal.
 - b. Glass.
 - c. Glazed surfaces of ceramic tile.
- B. Joint Priming: Prime joint substrates where recommended in writing by joint sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

- C. Masking Tape: Use masking tape where required to prevent contact of sealant with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.03 INSTALLATION OF JOINT SEALANTS

- A. General: Comply with joint sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
- B. Sealant Installation Standard: Comply with recommendations of ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- C. Acoustical Sealant Application Standard: Comply with recommendations of ASTM C 919 for use of joint sealants in acoustical applications as applicable to materials, applications, and conditions indicated.
- D. Install sealant backings of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 - 1. Do not leave gaps between ends of sealant backings.
 - 2. Do not stretch, twist, puncture, or tear sealant backings.
 - 3. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry materials.
- E. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and back of joints.
- F. Install sealants by proven techniques to comply with the following and at the same time backings are installed:
 - 1. Place sealants so they directly contact and fully wet joint substrates.
 - 2. Completely fill recesses provided for each joint configuration.
 - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- G. Tooling of Non-sag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
 - 1. Remove excess sealants from surfaces adjacent to joint.
 - 2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
 - 3. Provide concave joint configuration per Figure 5A in ASTM C 1193, unless otherwise indicated.

3.04 CLEANING

- A. Clean off excess sealants or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.05 PROTECTION

- A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from the original work.

3.06 ELASTOMERIC JOINT-SEALANT SCHEDULE

- A. Multicomponent Nonsag Urethane Sealant: Where joint sealants of this type are indicated, provide products complying with the following:
 - 1. Products: Available products include the following and approved equals:
 - a. Chem-Calk 500; Bostik Inc.
 - b. Dynatrol; Pecora Corporation.
 - c. Sikaflex - 2c NS; Sika Corporation.
 - d. Sonolastic NP 2; Sonneborn Building Products Div., ChemRex Inc.
 - 2. Type and Grade: M (multicomponent) and NS (nonsag).
 - 3. Class: 25.
 - 4. Use Related to Exposure: NT (nontraffic).
 - 5. Uses Related to Joint Substrates: M, G, A, and, as applicable to joint substrates indicated, O.
 - 6. Applications: Door perimeters, expansion and control joints in concrete and masonry.
- B. Multicomponent Nonsag Urethane Sealant: Where joint sealants of this type are indicated, provide products complying with the following:
 - 1. Available products include the following and approved equals:
 - a. Dyna Tred, Pecora Corporation.
 - b. Sikaflex-LCSL, Sika.
 - c. THG901, Tremco.
 - 2. Type and Grade: Type M, Grade P.
 - 3. Use Related to Exposure: T (traffic).
 - 4. Applications: Traffic Control Joints.

3.07 LATEX JOINT-SEALANT SCHEDULE

- A. Latex Sealant: Where joint sealants of this type are indicated, provide products complying with the following:
 - 1. Products:

- a. Chem-Calk 600; Bostik Inc.
 - b. NuFlex 330; NUCO Industries, Inc.
 - c. AC-20; Pecora Corporation.
 - d. PSI-701; Polymeric Systems, Inc.
 - e. Sonolac; Sonneborn Building Products Div., ChemRex, Inc.
 - f. Tremflex 834; Tremco.
2. Applications: Limit use to window, door and louver frames.

3.08 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 08330
ROLLING SERVICE DOORS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Rolling service doors.
- B. Springless rolling service doors.

1.02 RELATED SECTIONS

- A. Section 05500 "Miscellaneous Metal Fabrications": Support framing and framed opening.
- B. Section 09900 "Painting": Field applied finish.

1.03 REFERENCES

- A. ANSI/DASMA 108 - American National Standards Institute Standard Method For Testing Sectional Garage Doors And Rolling Doors: Determination Of Structural Performance Under Uniform Static Air Pressure Difference.
- B. NFRC 102 - Test Procedure for Measuring the Steady-State Thermal Transmittance of Fenestration Systems.
- C. ASTM E 90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Element.
- D. ASTM E 330 - Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference.
- E. ASTM A 653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

ASTM A 666 - Standard Specification for Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
- F. ASTM A 924 - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
- G. ASTM B 221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.

1.04 DESIGN / PERFORMANCE REQUIREMENTS

- A. Single-Source Responsibility: Provide doors, tracks, motors, and accessories from one manufacturer for each type of door. Provide secondary components from source acceptable to manufacturer of primary components.

1.05 SUBMITTALS

- A. Submit under provisions of Section 01300.
- B. Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Details of construction and fabrication.
 - 4. Installation instructions.
- C. Shop Drawings: Include detailed plans, elevations, details of framing members, anchoring methods, required clearances, hardware, and accessories. Include relationship with adjacent construction.
- D. Selection Samples: For each finish product specified, two complete sets of color chips representing manufacturer's full range of available colors and patterns.
- E. Verification Samples: For each finish product specified, two samples, minimum size 6 inches long, representing actual product, color, and patterns.
- F. Manufacturer's Certificates: Certify products meet or exceed specified requirements.
- G. Operation and Maintenance Data: Submit lubrication requirements and frequency, and periodic adjustments required.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in performing Work of this section with a minimum of five years experience in the fabrication and installation of security closures.
- B. Installer Qualifications: Company specializing in performing Work of this section with minimum three years and approved by manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Protect materials from exposure to moisture. Do not deliver until after wet work is complete and dry.
- C. Store materials in a dry, warm, ventilated weathertight location.

1.08 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

1.09 COORDINATION

- A. Coordinate Work with other operations and installation of adjacent materials to avoid damage to installed materials.

1.10 WARRANTY

- A. Warranty: Manufacturer's limited door and operator system, to be free from defects in materials and workmanship for 3 years or 500,000 cycles, whichever occurs first.
- B. PowderGuard Finish
 - 1. PowderGuard Premium Applied to curtain, guides, bottom bar, headplates: Manufacturer's limited Premium Finish warranty for 2 years.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Acceptable Manufacturer: Overhead Door Corporation, 2501 S. State Hwy. 121, Suite 200, Lewisville, TX 75067. ASD. Tel. Toll Free: (800) 275-3290. Phone: (469) 549-7100. Fax: (972) 906-1499. Web Site: www.overheaddoor.com. E-mail: info@overheaddoor.com.
- B. Substitutions: Subject to compliance with requirements, alternate suppliers will be permitted.

2.02 ROLLING SERVICE DOORS

- A. Industrial Doors: Overhead Door Corporation, Model 610 Rolling Service Doors.
 - 1. Curtain: Interlocking roll-formed slats as specified following. Endlocks shall be attached to each end of alternate slats to prevent lateral movement.
 - a. Flat profile type F-265 for doors up to 18 feet 4 inches (5.59 m) wide, fabricated of:
 - (i) 0.040-inch aluminum.
 - 2. Slats and Hood Finish:
 - a. Aluminum: Slats and hood finished as follows:
 - b. Powder Coat: Powder Guard Premium powder coat, color as selected by the Architect.
 - 3. Non-galvanized exposed ferrous surfaces shall receive one coat of rust-inhibitive primer.
 - 4. Weatherseals:
 - a. Vinyl bottom seal.
 - b. Guide weatherseal.
 - 5. Bottom Bar:
 - a. Extruded aluminum for doors up to 15 feet 4 inches (4.67 m) wide.
 - 6. Guides: Three structural steel angles.
 - 7. Brackets:

- a. Galvanized steel to support counterbalance, curtain and hood.
- 8. 7. Finish; Bottom Bar, Guides and Brackets:
 - a. PowderGuard Premium powder coat in black color.
- 9. Counterbalance: Helical torsion spring type housed in a steel tube or pipe barrel, supporting the curtain with deflection limited to 0.03 inch per foot of span. Counterbalance is adjustable by means of an adjusting tension wheel.
- 10. Hood:
 - a. 24-gauge galvanized steel with intermediate supports as required.
- 11. Manual Operation:
 - a. Chain hoist for doors over 96 SF.
- 12. Wind Load Design:
 - a. Standard wind load shall be 30 PSF.
- 13. Operation: Design door assembly, including operator, to operate for not less than 20,000 cycles.
- 14. Locking:
 - a. Two interior bottom bar slide bolts for manually operated doors.
 - b. Chain keeper locks for chain hoist operation.
- 15. Wall Mounting Condition:
 - a. Face-of-wall mounting.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify opening sizes, tolerances and conditions are acceptable.
- B. Examine conditions of substrates, supports, and other conditions under which this work is to be performed.
- C. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.02 PREPARATION

- A. Clean surfaces thoroughly prior to installation.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.03 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Use anchorage devices to securely fasten assembly to wall construction and building framing without distortion or stress.
- C. Securely and rigidly brace components suspended from structure. Secure guides to structural members only.

- D. Fit and align assembly including hardware; level and plumb, to provide smooth operation.
- E. Coordinate installation of sealants and backing materials at frame perimeter as specified in Section 07920.
- F. Install perimeter trim and closures.
- G. Instruct Owner's personnel in proper operating procedures and maintenance schedule.

3.04 ADJUSTING

- A. Test for proper operation and adjust as necessary to provide proper operation without binding or distortion.
- B. Adjust hardware and operating assemblies for smooth and noiseless operation.

3.05 CLEANING

- A. Clean curtain and components using non-abrasive materials and methods recommended by manufacturer.
- B. Remove labels and visible markings.
- C. Touch-up, repair or replace damaged products before Substantial Completion.

3.06 PROTECTION

- A. Protect installed products until completion of project.

3.07 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 09220

PORTLAND CEMENT PLASTERING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Exterior vertical plasterwork (stucco).
 - 2. Exterior horizontal and nonvertical plasterwork (stucco).

1.03 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.04 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Show locations and installation of control and expansion joints, including plans, elevations, sections, details of components, and attachments to other work.

1.05 DESIGN REQUIREMENTS

- A. Structural (wind and axial loads)
 - 1. Design for maximum allowable deflection, normal to the plan of the wall of L/360.
 - 2. Design for wind load in conformance with code requirements. Consult applicable code compliance report for limitations that may apply.
- B. Moisture Control
 - 1. Prevent the accumulation of water into or behind the stucco, either by condensation or leakage into the wall construction, in the design and detailing of the wall assembly.
- C. Joints
 - 1. Provide on piece control joints every 250 SF. Do not exceed length to width ratio of 2-1/2:1 in control joint layout and do not exceed more than 18 feet in any direction without an expansion or control joint. Where casing beads are used back to back as the joint accessories, back the joint with appropriate StoGuard transition or backer material, however, do not allow transition/backer material to extend beyond the expanded flange (as stucco will not adhere to StoGuard).
 - 2. Provide appropriate accessories at stucco terminations and joints.

3. Provide appropriate sealant at stucco terminations and at accessory butt joints so they are watertight.

D. Surface Conditions and Surface Preparation

1. Provide surface plane tolerance not to exceed 1/4 inch in 10 feet.
2. Remove form ties, trim projecting concrete and fill honeycombs or other surface defects with appropriate patch and repair material.
3. Concrete Masonry-provide open texture concrete masonry units with flush joints, free of efflorescence, coatings or other surface contamination, weak surfaces or surface conditions that could interfere with adhesion.
4. Do not install stucco, stucco bonding agent, primers or finishes over efflorescence, laitance or weak surface conditions, painted, coated or salt contaminated, non-absorbent, smooth or high-density concrete surfaces, or any concrete or CMU substrate where adhesion is in question, or when total stucco thickness (including finish coat will exceed 5/8". Use appropriate metal plaster base in these cases.

E. Stucco Thickness

1. Scratch Coat: 1/4 inch uniform thickness.
2. Brown Coat: 1/4 inch uniform thickness.
3. Finish Coat: uniform, and in accordance with published instructions of Manufacturer. Finish to align with existing finish to remain.

1.06 PERFORMANCE REQUIREMENTS

A. Primers

1. Alkaline Resistant Primer for freshly placed (minimum 4 day old) stucco surfaces:
 - a. Resistant to alkaline surfaces with pH of 13 or less.
 - b. Surface Burning, ASTM E 84: Flame Spread less than 25, Smoke Developed less than 450, Class A building material.
 - c. VOC: less than 50 g/L, compliant with South Coast AQMD Rule 1113 for architectural coatings.

1.07 QUALITY ASSURANCE

A. Manufacturer requirements

1. Stucco products manufacturer for a minimum of twenty-five (25) years.

B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.

1. Build mockups for each substrate and finish texture indicated for cement plastering, including accessories.
 - a. Size: 100 sq. ft. (9 sq. m) in surface area.
2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver all materials in their original sealed containers bearing Manufacturer's name and identification of product.
- B. Protect coatings (pail products) from freezing and temperatures in excess of 90 degrees F. Store away from direct sunlight.
- C. Protect portland cement-based materials (bag products) from moisture and humidity. Store under cover off the ground in a dry location.

1.09 FIELD CONDITIONS

- A. Comply with ASTM C926 requirements.
- B. Exterior Plasterwork:
 - 1. Apply and cure plaster to prevent plaster drying out during curing period. Use procedures required by climatic conditions, including moist curing, providing coverings, and providing barriers to deflect sunlight and wind.
 - 2. Apply plaster when ambient temperature is greater than 40 deg F.
 - 3. Protect plaster coats from freezing for not less than 48 hours after set of plaster coat has occurred.
- C. Factory-Prepared Finishes: Comply with manufacturer's written recommendations for environmental conditions for applying finishes.

1.10 SUBMITTALS

- A. Manufacturer's guide specifications, guide details, installation instructions and product data.
- B. Manufacturer's code compliance report.
- C. Manufacturer's standard warranty.
- D. Samples for approval as directed by architect or Owner.

PART 2 PRODUCTS

2.01 METAL LATH

- A. Expanded-Metal Lath: ASTM C847, cold-rolled carbon-steel sheet with ASTM A653/A653M, G60 (Z180), hot-dip galvanized-zinc coating.
- B. Paper Backing: FS UU-B-790a, Type I, Grade B, Style 1a vapor-retardant paper.
 - 1. Provide paper-backed lath unless otherwise indicated.

2.02 ACCESSORIES

- A. General: Comply with ASTM C1063, and coordinate depth of trim and accessories with thicknesses and number of plaster coats required.

B. Metal Accessories:

1. Foundation Weep Screed: Fabricated from hot-dip galvanized-steel sheet, ASTM A653/A653M, G60 (Z180) zinc coating.
2. Cornerite: Fabricated from metal lath with ASTM A653/A653M, G60 (Z180), hot-dip galvanized-zinc coating.
3. External- (Outside-) Corner Reinforcement: Fabricated from metal lath with ASTM A653/A653M, G60 (Z180), hot-dip galvanized-zinc coating.
4. Cornerbeads: Fabricated from zinc or zinc-coated (galvanized) steel.
 - a. Smallnose cornerbead with expanded flanges; use unless otherwise indicated.
5. Casing Beads: Fabricated from zinc or zinc-coated (galvanized) steel; square-edged style; with expanded flanges.
6. Control Joints: Fabricated from zinc or zinc-coated (galvanized) steel; one-piece-type, folded pair of unperforated screeds in M-shaped configuration; with perforated flanges and removable protective tape on plaster face of control joint.
7. Expansion Joints: Fabricated from zinc or zinc-coated (galvanized) steel; folded pair of unperforated screeds in M-shaped configuration; with expanded flanges.

C. Plastic Accessories: Manufactured from high-impact PVC.

1. Cornerbeads: With perforated flanges.
 - a. Smallnose cornerbead; use unless otherwise indicated.
2. Casing Beads: With perforated flanges in depth required to suit plaster bases indicated and flange length required to suit applications indicated.
 - a. Square-edge style; use unless otherwise indicated.
3. Control Joints: One-piece-type, folded pair of unperforated screeds in M-shaped configuration; with perforated flanges and removable protective tape on plaster face of control joint.

2.03 MISCELLANEOUS MATERIALS

- A. Water for Mixing and Finishing Plaster: Potable and free of substances capable of affecting plaster set or of damaging plaster, lath, or accessories.
- B. Fiber for Base Coat: Alkaline-resistant glass or polypropylene fibers, 1/2 inch long, free of contaminants, manufactured for use in cement plaster.
- C. Bonding Compound: ASTM C932.
- D. Fasteners for Attaching Metal Lath to Substrates: ASTM C1063.
- E. Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper, not less than 0.0475-inch diameter unless otherwise indicated.

2.04 PLASTER MATERIALS

- A. Portland Cement: ASTM C150/C150M, Type II.
 1. Color for Finish Coats: White.
- B. Masonry Cement: ASTM C91, Type N.

1. Color for Finish Coats: White.
- C. Lime: ASTM C206, Type S; or ASTM C207, Type S.
- D. Sand Aggregate: ASTM C897.
 1. Color for Job-Mixed Finish Coats: White.

2.05 PLASTER MIXES

- A. General: Comply with ASTM C926 for applications indicated.
 1. Fiber Content: Add fiber to base-coat mixes after ingredients have mixed at least two minutes. Comply with fiber manufacturer's written instructions for fiber quantities in mixes, but do not exceed 1 lb of fiber/cu. yd. (0.6 kg of fiber/cu. m) of cementitious materials.
- B. Base-Coat Mixes for Use over Metal Lath: Scratch and brown coats for three-coat plasterwork as follows:
 1. Portland Cement Mixes:
 - a. Scratch Coat: For cementitious material, mix 1 part portland cement and 3/4 to 1-1/2 parts lime. Use 2-1/2 to 4 parts aggregate per part of cementitious material.
 - b. Brown Coat: For cementitious material, mix 1 part portland cement and 3/4 to 1-1/2 parts lime. Use 3 to 5 parts aggregate per part of cementitious material, but not less than volume of aggregate used in scratch coat.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Protect adjacent work from soiling, spattering, moisture deterioration, and other harmful effects caused by plastering.
- B. Prepare smooth, solid substrates for plaster according to ASTM C926.

3.03 INSTALLING METAL LATH

- A. Metal Lath: Install according to ASTM C1063.
 1. On Solid Surfaces, Not Otherwise Furred: Install self-furring, diamond-mesh lath.

3.04 INSTALLING ACCESSORIES

- A. Install according to ASTM C1063 and at locations indicated on Drawings.

- B. Reinforcement for External (Outside) Corners:
 - 1. Install lath-type, external-corner reinforcement at exterior locations.
 - 2. Install cornerbead at interior locations.
- C. Control Joints: Locate as approved by Architect for visual effect and as follows:
 - 1. As required to delineate plasterwork into areas (panels) of the following maximum sizes:
 - a. Vertical Surfaces: 144 sq. ft. (13.4 sq. m).
 - b. Horizontal and Other Nonvertical Surfaces: 100 sq. ft. (9.3 sq. m).
 - 2. At distances between control joints of not greater than 18 feet (5.5 m) o.c.
 - 3. As required to delineate plasterwork into areas (panels) with length-to-width ratios of not greater than 2-1/2:1.
 - 4. Where control joints occur in surface of construction directly behind plaster.
 - 5. Where plasterwork areas change dimensions, to delineate rectangular-shaped areas (panels) and to relieve the stress that occurs at the corner formed by the dimension change.

3.05 PLASTER APPLICATION

- A. General: Comply with ASTM C926.
 - 1. Do not deviate more than plus or minus 1/4 inch in 10 feet from a true plane in finished plaster surfaces when measured by a 10-foot (3-m) straightedge placed on surface.
 - 2. Finish plaster flush with metal frames and other built-in metal items or accessories that act as a plaster ground unless otherwise indicated. Where casing bead does not terminate plaster at metal frame, cut base coat free from metal frame before plaster sets and groove finish coat at junctures with metal.
 - 3. Provide plaster surfaces that are ready to receive field-applied finishes indicated.
- B. Walls; Base-Coat Mixes for Use over Metal Lath: For scratch and brown coats, for three-coat plasterwork with 3/4-inch total thickness, as follows:
 - 1. Portland cement mixes.
- C. Ceilings; Base-Coat Mixes for Use over Metal Lath: For scratch and brown coats, for three-coat plasterwork and having 1/2-inch total thickness, as follows:
 - 1. Portland cement mixes.
- D. Plaster Finish Coats: Apply to match existing finish to remain.

3.06 PLASTER REPAIRS

- A. Repair or replace work to eliminate cracks, dents, blisters, buckles, crazing and check cracking, dry outs, efflorescence, sweat outs, and similar defects and where bond to substrate has failed.

3.07 CLEANING AND PROTECTION

- A. Remove temporary protection and enclosure of other work after plastering is complete. Promptly remove plaster from door frames, windows, and other surfaces not indicated to be plastered. Repair floors, walls, and other surfaces stained, marred, or otherwise damaged during plastering.

3.08 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 09900

PAINTING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply herein.

1.02 SUMMARY

- A. This Section includes surface preparation and field painting of the following:
 - 1. Exposed exterior items and surfaces.
 - 2. Exposed interior items and surfaces.
 - 3. Surface preparation, priming, and finish coats specified herein are in addition to shop priming and surface treatment specified in other Sections.
- B. Paint exposed surfaces, except where the paint schedules indicate that a surface or material is not to be painted or is to remain natural. If the paint schedules do not specifically mention an item or a surface, paint the item or surface the same as similar adjacent materials or surfaces whether or not schedules indicate colors. If the schedules do not indicate color or finish, the OWNER and/or ENGINEER will select from standard colors and finishes available.
- C. Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels.
 - 1. Prefinished items include the following factory-finished components:
 - a. Architectural casework.
 - b. Finished mechanical and electrical equipment.
 - c. Light fixtures.
 - d. Distribution cabinets.
 - 2. Finished metal surfaces include the following:
 - a. Anodized aluminum.
 - b. Stainless steel.
 - 3. Labels: Do not paint over Underwriters Laboratories (UL), Factory Mutual (FM), or other code-required labels or equipment name, identification, performance rating, or nomenclature plates.

1.03 DEFINITIONS

- A. General: Standard coating terms defined in ASTM D 16 apply herein.
 - 1. Flat refers to a lusterless or matte finish with a gloss range below 15 when measured at an 85-degree meter.
 - 2. Eggshell refers to low-sheen finish with a gloss range between 5 and 20 when measured at a 60-degree meter.

3. Satin refers to low-sheen finish with a gloss range between 15 and 35 when measured at a 60-degree meter.
4. Semigloss refers to medium-sheen finish with a gloss range between 30 and 65 when measured at a 60-degree meter.
5. Full gloss refers to high-sheen finish with a gloss range more than 65 when measured at a 60-degree meter.

1.04 SUBMITTALS

- A. Product Data: For each paint system specified. Include block fillers and primers.
- B. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for each type of finish-coat material indicated.

1.05 QUALITY ASSURANCE

- A. Applicator Qualifications: Engage an experienced applicator who has completed painting system applications similar in material and extent to that indicated for this Project with a record of successful in-service performance.
- B. Source Limitations: Obtain block fillers, primers, and undercoat materials for each coating system from the same Manufacturer as the finish coats.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to the Project Site in Manufacturer's original, unopened packages and containers bearing Manufacturer's name and label, and the following information:
 1. Product name or title of material.
 2. Product description (generic classification or binder type).
 3. Manufacturer's stock number and date of manufacture.
 4. Contents by volume, for pigment and vehicle constituents.
 5. Thinning instructions.
 6. Application instructions.
 7. Color name and number.
 8. VOC content.
- B. Store materials not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature of 45 deg F (7 deg C). Maintain containers used in storage in a clean condition, free of foreign materials and residue.
 1. Protect from freezing. Keep storage area neat and orderly. Remove oily rags and waste daily. Take necessary measures to ensure that workers and work areas are protected from fire and health hazards resulting from handling, mixing, and application.

1.07 PROJECT CONDITIONS

- A. Apply water-based paints only when the temperature of surfaces to be painted and surrounding air temperatures are between 50 and 90 deg F (10 and 32 deg C).

- B. Apply solvent-thinned paints only when the temperature of surfaces to be painted and surrounding air temperatures are between 45 and 95 deg F (7.2 and 35 deg C).
- C. Do not apply paint in snow, rain, fog, or mist; or when the relative humidity exceeds 85 percent; or at temperatures less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.
 - 1. Painting may continue during inclement weather if surfaces and areas to be painted are enclosed and heated within temperature limits specified by Manufacturer during application and drying periods.

1.08 EXTRA MATERIALS

- A. Furnish extra paint materials from the same production run as the materials applied in the quantities described below. Package paint materials in unopened, factory-sealed containers for storage and identify with labels describing contents. Deliver extra materials to the OWNER.
 - 1. Quantity: Furnish the OWNER with 1 gallon of each color and each type of paint used on the project.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products listed in the paint schedules. For all paint classifications, Sherwin Williams Co. (S-W) products are listed as representative examples. Products from other Manufacturers that can be demonstrated to be equal in composition and material properties will also be acceptable upon approval by the OWNER and/or ENGINEER.

2.02 PAINT MATERIALS, GENERAL

- A. Material Compatibility: Provide primers, undercoats, and finish-coat materials that are compatible with one another and the substrates indicated under conditions of service and application, as demonstrated by Manufacturer based on testing and field experience.
- B. Material Quality: Provide Manufacturer's best-quality paint material of the various coating types specified. Paint-material containers not displaying Manufacturer's product identification will not be acceptable.
 - 1. Proprietary Names: Use of Manufacturer's proprietary product names to designate colors or materials is not intended to imply that products named are required to be used to the exclusion of equivalent products of other Manufacturers. Furnish Manufacturer's material data and certificates of performance for proposed substitutions.
- C. Colors: Provide color selections made by the OWNER and/or ENGINEER.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with the Applicator present, under which painting will be performed for compliance with paint application requirements.
 - 1. Do not begin to apply paint until unsatisfactory conditions have been corrected and surfaces receiving paint are thoroughly dry.
 - 2. Start of painting will be construed as the Applicator's acceptance of surfaces and conditions within a particular area.
- B. Coordination of Work: Review other Sections in which primers are provided to ensure compatibility of the total system for various substrates.

3.02 PREPARATION

- A. General: Remove hardware and hardware accessories, plates, machined surfaces, lighting fixtures, and similar items already installed that are not to be painted. If removal is impractical or impossible because of the size or weight of the item, provide surface-applied protection before surface preparation and painting.
 - 1. After completing painting operations in each space or area, reinstall items removed using workers skilled in the trades involved.
- B. Cleaning: Before applying paint or other surface treatments, clean the substrates of substances that could impair the bond of the various coatings. Remove oil and grease before cleaning.
 - 1. Schedule cleaning and painting so dust and other contaminants from the cleaning process will not fall on wet, newly painted surfaces.
- C. Surface Preparation: Clean and prepare surfaces to be painted according to Manufacturer's written instructions for each particular substrate condition and as specified.
 - 1. Provide barrier coats over incompatible primers or remove and reprime.
 - 2. Ferrous Metals: Clean ungalvanized ferrous-metal surfaces that have not been shop coated; remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with the Steel Structures Painting Council's (SSPC) recommendations.
 - a. Treat bare and sandblasted or pickled clean metal with a metal treatment wash coat before priming.
 - b. Touch up bare areas and shop-applied prime coats that have been damaged. Wire-brush, clean with solvents recommended by the paint Manufacturer, and touch up with the same primer as the shop coat.
 - 3. Galvanized Surfaces: Clean galvanized surfaces with nonpetroleum-based solvents so surface is free of oil and surface contaminants. Remove pretreatment from galvanized sheet metal fabricated from coil stock by mechanical methods.
- D. Materials Preparation: Mix and prepare paint materials according to the Manufacturer's written instructions.

1. Maintain containers used in mixing and applying paint in a clean condition, free of foreign materials and residue.
2. Stir material before application to produce a mixture of uniform density. Stir as required during application. Do not stir surface film into material. If necessary, remove surface film and strain material before using.
3. Use only thinners approved by paint Manufacturer and only within recommended limits.

3.03 APPLICATION

- A. General: Apply paint according to Manufacturer's written instructions. Use applicators and techniques best suited for substrate and type of material being applied.
 1. Paint colors, surface treatments, and finishes are indicated in the schedules.
 2. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to formation of a durable paint film.
 3. Provide finish coats that are compatible with primers used.
 4. The term "exposed surfaces" includes areas visible when permanent or built-in fixtures are in place. Extend coatings in these areas, as required.
 5. Paint surfaces behind movable equipment and furniture the same as similar exposed surfaces. Before the final installation of equipment, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
 6. Paint interior surfaces of ducts with a flat, nonspecular black paint where visible through registers or grilles.
 7. Finish exterior doors on tops, bottoms, and side edges the same as exterior faces.
- B. Scheduling Painting: Apply first coat to surfaces that have been cleaned, pretreated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.
 1. The number of coats and the film thickness required are the same regardless of application method. Do not apply succeeding coats until the previous coat has cured as recommended by the Manufacturer. If sanding is required to produce a smooth, even surface according to Manufacturer's written instructions, sand between applications.
 2. Omit primer on metal surfaces that have been shop primed and touchup painted.
 3. If undercoats, stains, or other conditions show through final coat of paint, apply additional coats until paint film is of uniform finish, color, and appearance. Give special attention to ensure edges, corners, crevices, welds, and exposed fasteners receive a dry film thickness equivalent to that of flat surfaces.
 4. Allow sufficient time between successive coats to permit proper drying. Do not recoat surfaces until paint has dried to where it feels firm, does not deform or feel sticky under moderate thumb pressure, and where application of another coat of paint does not cause the undercoat to lift or lose adhesion.
- C. Application Procedures: Apply paints and coatings by brush, roller, spray, or other applicators according to Manufacturer's written instructions.
 1. Brushes: Use brushes best suited for the type of material applied. Use brush of appropriate size for the surface or item being painted.

2. Rollers: Use rollers of carpet, velvet back, or high-pile sheep's wool as recommended by the Manufacturer for the material and texture required.
 3. Spray Equipment: Use airless spray equipment with orifice size as recommended by the Manufacturer for the material and texture required.
- D. Minimum Coating Thickness: Apply paint materials no thinner than Manufacturer's recommended spreading rate. Provide the total dry film thickness of the entire system as recommended by the Manufacturer.
- E. Prime Coats: Before applying finish coats, apply a prime coat of material, as recommended by the Manufacturer, to material that is required to be painted or finished and that has not been prime coated by others. Recoat primed and sealed surfaces where evidence of suction spots or unsealed areas in first coat appears, to ensure a finish coat with no burn through or other defects due to insufficient sealing.
- F. Pigmented (Opaque) Finishes: Completely cover surfaces as necessary to provide a smooth, opaque surface of uniform finish, color, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections will not be acceptable.
- G. Transparent (Clear) Finishes: Use multiple coats to produce a glass-smooth surface film of even luster. Provide a finish free of laps, runs, cloudiness, color irregularity, brush marks, orange peel, nail holes, or other surface imperfections.
1. Provide satin finish for final coats.
- H. Stipple Enamel Finish: Roll and redistribute paint to an even and fine texture. Leave no evidence of rolling, such as laps, irregularity in texture, skid marks, or other surface imperfections.
- I. Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or repaint work not complying with requirements.

3.04 CLEANING

- A. Cleanup: At the end of each workday, remove empty cans, rags, rubbish, and other discarded paint materials from the site.
1. After completing painting, clean glass and paint-spattered surfaces. Remove spattered paint by washing and scraping. Be careful not to scratch or damage adjacent finished surfaces.

3.05 PROTECTION

- A. Protect work of other trades, whether being painted or not, against damage by painting. Correct damage by cleaning, repairing or replacing, and repainting, as approved by the OWNER and/or ENGINEER.

3.06 EXTERIOR PAINT SCHEDULE

- A. Ferrous Metal: Provide the following finish systems over exterior ferrous metal. Primer is not required on shop-primed items.

1. Full-Gloss, Alkyd-Enamel Finish: 2 finish coats over a rust-inhibitive primer.
 - a. Primer: Rust-inhibitive metal primer applied at spreading rate recommended by the Manufacturer to achieve a total dry film thickness of not less than 1.3 mils (0.033 mm).
 - (i) S-W: Kem Kromik Metal Primer B50N2/B50W1.
 - b. First and Second Coats: Full-gloss, exterior, alkyd enamel applied at spreading rate recommended by the Manufacturer to achieve a total dry film thickness of not less than 3.0 mils (0.076 mm).
 - (i) S-W: Industrial Enamel B-54 Series.
 2. Deep-Color, Full-Gloss, Alkyd-Enamel Finish: 2 finish coats over a rust-inhibitive primer.
 - a. Primer: Rust-inhibitive metal primer applied at spreading rate recommended by the Manufacturer to achieve a total dry film thickness of not less than 1.4 mils (0.036 mm).
 - (i) S-W: Kem Kromik Metal Primer B50N2/B50W1.
 - b. First and Second Coats: Deep-color, full-gloss, exterior, alkyd enamel applied at spreading rate recommended by the Manufacturer to achieve a total dry film thickness of not less than 3.7 mils (0.094 mm).
 - (i) S-W: SWP Exterior Gloss Paint A-2 Series.
- B. Zinc-Coated Metal: Provide the following finish systems over exterior zinc-coated (galvanized) metal surfaces:
1. Full-Gloss, Alkyd-Enamel Finish: 2 finish coats over a galvanized metal primer.
 - a. Primer: Galvanized metal primer applied at spreading rate recommended by the Manufacturer to achieve a total dry film thickness of not less than 1.2 mils (0.031 mm).
 - (i) S-W: Galvite Paint B50W3.
 - b. First and Second Coats: Full-gloss, exterior, alkyd enamel applied at spreading rate recommended by the Manufacturer to achieve a total dry film thickness of not less than 2.6 mils (0.066 mm).
 - (i) S-W: Industrial Enamel B-54 Series.

3.07 INTERIOR PAINT SCHEDULE

- A. Ferrous Metal: Provide the following finish systems over ferrous metal:
1. Full-Gloss, Alkyd-Enamel Finish: 2 finish coats over an enamel undercoater and a primer.
 - a. Primer: Quick-drying, rust-inhibitive, alkyd-based or epoxy-metal primer, as recommended by the Manufacturer for this substrate, applied at spreading rate recommended by the Manufacturer to achieve a total dry film thickness of not less than 1.5 mils (0.038 mm).
 - (i) S-W: Kem Kromik Metal Primer B50N2/B50W1.
 - b. Undercoat: Alkyd, interior enamel undercoat or full-gloss, interior, alkyd-enamel finish coat, as recommended by the Manufacturer for this substrate, applied at spreading rate recommended by the Manufacturer to achieve a total dry film thickness of not less than 1.2 mils (0.031 mm).

- (i) S-W: Industrial Enamel B-54 Series.
 - c. Finish Coat: Full-gloss, alkyd, interior enamel applied at spreading rate recommended by the Manufacturer to achieve a total dry film thickness of not less than 1.2 mils (0.031 mm).
 - (i) S-W: Industrial Enamel B-54 Series.
- B. Zinc-Coated Metal: Provide the following finish systems over exterior zinc-coated (galvanized) metal surfaces:
 - 1. Full-Gloss, Alkyd-Enamel Finish: 2 finish coats over a galvanized metal primer.
 - a. Primer: Galvanized metal primer applied at spreading rate recommended by the Manufacturer to achieve a total dry film thickness of not less than 1.2 mils (0.031 mm).
 - (i) S-W: Galvite Paint B50W3.
 - b. First and Second Coats: Full-gloss, exterior, alkyd enamel applied at spreading rate recommended by the Manufacturer to achieve a total dry film thickness of not less than 2.6 mils (0.066 mm).
 - (i) S-W: Industrial Enamel B-54 Series.

3.08 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 09911

EXTERIOR ARCHITECTURAL PAINTING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section includes surface preparation and the application of paint systems on exterior substrates.
 - 1. Concrete.
 - 2. Fiber-cement board.
 - 3. Clay masonry.
 - 4. Concrete masonry units (CMU).
 - 5. Steel.
 - 6. Galvanized metal.
 - 7. Aluminum (not anodized or otherwise coated).
 - 8. Stainless-steel flashing.
 - 9. Wood.
 - 10. Plastic trim fabrications.
 - 11. Exterior portland cement plaster (stucco).
 - 12. Exterior gypsum board.
- B. Related Requirements:
 - 1. Section 09912 "Interior Architectural Painting" for surface preparation and the application of paint systems on interior substrates.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include preparation requirements and application instructions.
 - 1. Indicate VOC content.
- B. Samples for Initial Selection: For each type of topcoat product.
- C. Samples for Verification: For each type of paint system and each color and gloss of topcoat.
 - 1. Submit Samples on rigid backing, 8 inches (200 mm) square.
 - 2. Label each coat of each Sample.
 - 3. Label each Sample for location and application area.
- D. Product List: For each product indicated, include the following:

1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
2. Indicate VOC content.

1.04 CLOSEOUT SUBMITTALS

- A. Coating Maintenance Manual: Provide coating maintenance manual including area summary with finish schedule, area detail designating location where each product/color/finish was used, product data pages, material safety data sheets, care and cleaning instructions, touch-up procedures, and color samples of each color and finish used.

1.05 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Paint: 1 gal. (3.8 L) of each material and color applied.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Delivery and Handling: Deliver products to Project site in an undamaged condition in manufacturer's original sealed containers, complete with labels and instructions for handling, storing, unpacking, protecting, and installing. Packaging shall bear the manufacturer's label with the following information:
 1. name and type (description).
 2. Batch date.
 3. Color number.
 4. VOC content.
 5. Environmental handling requirements.
 6. Surface preparation requirements.
 7. Application instructions.
- B. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).
 1. Maintain containers in clean condition, free of foreign materials and residue.
 2. Remove rags and waste from storage areas daily.

1.07 FIELD CONDITIONS

- A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).
- B. Do not apply paints in snow, rain, fog, or mist; when relative humidity exceeds 85 percent; at temperatures less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.
- C. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.

1. If suspected hazardous materials are encountered, do not disturb; immediately notify Architect and Owner.
- D. Hazardous Materials: Hazardous materials including lead paint may be present in buildings and structures to be painted. A report on the presence of known hazardous materials is on file for review and use. Examine report to become aware of locations where hazardous materials are present.
 1. Do not disturb hazardous materials or items suspected of containing hazardous materials except under procedures specified.
 2. Perform preparation for painting of substrates known to include lead paint in accordance with EPA Renovation, Repair and Painting Rule and additional requirements of authorities having jurisdiction.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Sherwin-Williams Company (The); products indicated or comparable product from one of the following:
 1. Benjamin Moore & Co.
 2. PPG Architectural Coatings.
 3. Valspar Corporation - Architectural (Pro).
- B. Comparable Products: Comparable products of approved manufacturers will be considered in accordance with Section 01600 "Materials and Equipment" and the following:
 1. Products are approved by manufacturer in writing for application specified.
 2. Products meet performance and physical characteristics of basis of design product including published ratio of solids by volume, plus or minus two percent.
- C. Source Limitations: Obtain paint materials from single source from single listed manufacturer.
 1. Manufacturer's designations listed on a separate color schedule are for color reference only and do not indicate prior approval.

2.02 PAINT, GENERAL

- A. Material Compatibility:
 1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.
- B. VOC Content: For field applications, provide paints and coatings that complies with VOC content limits of authorities having jurisdiction.
- C. Colors: As selected by Architect from manufacturer's full range.

1. 20 percent of surface area will be painted with deep tones.

2.03 SOURCE QUALITY CONTROL

- A. Testing of Paint Materials: Owner reserves the right to invoke the following procedure:
 1. Owner will engage the services of a qualified testing agency to sample paint materials. Contractor will be notified in advance and may be present when samples are taken. If paint materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
 2. Testing agency will perform tests for compliance with product requirements.
 3. Owner may direct Contractor to stop applying paints if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying paint materials from Project site, pay for testing, and repaint surfaces painted with rejected materials. Contractor will be required to remove rejected materials from previously painted surfaces if, on repainting with complying materials, the two paints are incompatible.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers. Where acceptability of substrate conditions is in question, apply samples and perform in-situ testing to verify compatibility, adhesion, and film integrity of new paint application.
 1. Report, in writing, conditions that may affect application, appearance, or performance of paint.
- B. Substrate Conditions:
 1. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
 - a. Concrete: 12 percent.
 - b. Fiber-Cement Board: 12 percent.
 - c. Masonry (Clay and CMU): 12 percent.
 - d. Wood: 15 percent.
 - e. Portland Cement Plaster: 12 percent.
 - f. Gypsum Board: 12 percent.
 2. Portland Cement Plaster Substrates: Verify that plaster is fully cured.
 3. Exterior Gypsum Board Substrates: Verify that finishing compound is sanded smooth.
- C. Proceed with coating application only after unsatisfactory conditions have been corrected; application of coating indicates acceptance of surfaces and conditions.

3.02 PREPARATION

- A. Comply with manufacturer's written instructions and recommendations in "MPI Manual" applicable to substrates and paint systems indicated.
- B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
 - 1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection.
- C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
 - 1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.
- D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.
- E. Masonry Substrates: Remove efflorescence and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces or mortar joints exceeds that permitted in manufacturer's written instructions.
- F. Steel Substrates: Remove rust, loose mill scale, and shop primer if any. Clean using methods recommended in writing by paint manufacturer but not less than the following:
 - 1. SSPC-SP 2, "Hand Tool Cleaning."
 - 2. SSPC-SP 3, "Power Tool Cleaning."
 - 3. SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
 - 4. SSPC-SP 11, "Power Tool Cleaning to Bare Metal."
- G. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.
- H. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.
- I. Aluminum Substrates: Remove loose surface oxidation.
- J. Wood Substrates:
 - 1. Scrape and clean knots. Before applying primer, apply coat of knot sealer recommended in writing by topcoat manufacturer for exterior use in paint system indicated.
 - 2. Sand surfaces that will be exposed to view, and dust off.
 - 3. Prime edges, ends, faces, undersides, and backsides of wood.

4. After priming, fill holes and imperfections in the finish surfaces with putty or plastic wood filler. Sand smooth when dried.

- K. Plastic Trim Fabrication Substrates: Remove dust, dirt, and other foreign material that might impair bond of paints to substrates.

3.03 APPLICATION

- A. Apply paints according to manufacturer's written instructions and recommendations in "MPI Manual."
 1. Use applicators and techniques suited for paint and substrate indicated.
 2. Paint surfaces behind movable items same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed items with prime coat only.
 3. Paint both sides and edges of exterior doors and entire exposed surface of exterior door frames.
 4. Paint entire exposed surface of window frames and sashes.
 5. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
 6. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.
- B. Tint undercoats same color as topcoat, but tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Provide sufficient difference in shade of undercoats to distinguish each separate coat.
- C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.
- D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
- E. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:
 1. Paint the following work where exposed to view:
 - a. Equipment, including panelboards and switch gear.
 - b. Uninsulated metal piping.
 - c. Uninsulated plastic piping.
 - d. Pipe hangers and supports.
 - e. Metal conduit.
 - f. Plastic conduit.
 - g. Tanks that do not have factory-applied final finishes.

3.04 FIELD QUALITY CONTROL

- A. Dry Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry film thickness.
 1. Contractor shall touch up and restore painted surfaces damaged by testing.

2. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written recommendations.

3.05 CLEANING AND PROTECTION

- A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
- B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
- C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.
- D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.06 EXTERIOR PAINTING SCHEDULE

- A. Concrete, Clay Masonry, Portland Cement Plaster (Stucco), Cementitious Siding, Nontraffic Surfaces:
 1. Latex System:
 - a. Prime Coat: Primer sealer, latex.
 - (i) S-W Loxon Concrete & Masonry Primer Sealer, A24W8300, at 8.0 mils wet, 3.2 mils dry.
 - b. Prime Coat: Latex, exterior, matching topcoat.
 - c. Intermediate Coat: Latex, exterior, matching topcoat.
 - d. Topcoat: Latex, exterior, flat. wet, 1.2 mils dry, per coat.
 - e. Topcoat: Latex, exterior, low sheen.
 - (i) S-W A-100 Exterior Latex Low Sheen, A12 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - f. Topcoat: Latex, exterior, satin.
 - (i) S-W A-100 Exterior Latex Satin, A82 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - g. Topcoat: Latex, exterior, semi-gloss.
 - (i) S-W Solo Acrylic Semi-Gloss, A76 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - h. Topcoat: Latex, exterior, gloss.
 - (i) S-W A-100 Exterior Latex Gloss, A8 Series, at 4.0 mils wet, 1.3 mils dry, per coat.
 2. Latex over Latex Aggregate System:
 - a. Prime Coat: Block Filler, Latex, Interior/Exterior.

- (i) S-W Loxon Block Surfer, A24W200, at 50 to 100 sq. ft. per gal. (1.23 to 2.45 sq. m per liter).
 - b. Topcoat: Latex, exterior flat, medium texture.
 - (i) S-W UltraCrete Textured Masonry Topcoat, A44-800 Series, 50 to 80 sq. ft. per gal. (1.23 to 1.96 sq. m per liter).
 - 3. Concrete Stain System (Water-based):
 - a. First Coat: Low-luster opaque finish matching topcoat.
 - b. Topcoat: Low-luster opaque finish:
 - (i) S-W H&C Colortop Water-Based Solid Color Concrete Stain, at 50 to 250 sq. ft. per gal. (1.23 to 6.14 sq. m per liter).
- B. Concrete Substrates, Pedestrian Traffic Surfaces:
- 1. Latex Floor Paint System:
 - a. First Coat: Floor paint, latex, slip-resistant, matching topcoat.
 - b. Topcoat: Floor paint, latex, slip-resistant, low gloss.
 - (i) S-W ArmorSeal Tread-Plex, B90 Series, at 1.5 to 2.0 mils dry per coat.
 - 2. Concrete Stain System (Water-based) for Vertical Surfaces:
 - a. First Coat: Low-luster opaque finish matching top coat.
 - b. Topcoat: Low-luster opaque finish.
 - (i) S-W H&C Colortop Water-Based Solid Color Concrete Stain, at 50 to 250 sq. ft. per gal. (1.23 to 6.14 sq. m per liter).
- C. CMU Substrates:
- 1. Latex System:
 - a. Block Filler: Block filler, latex, interior/exterior:
 - b. S-W PrepRite Block Filler, B25W25, at 75 to 125 sq. ft. per gal. (1.84 to 3.07 sq. m per liter).
 - (i) Intermediate Coat: Latex, exterior, matching topcoat.
 - c. Topcoat: Latex, exterior, flat.
 - (i) S-W A-100 Exterior Latex Flat, A6 Series, at 4.0 mils wet, 1.2 mils dry, per coat.
 - d. Topcoat: Latex, exterior, low sheen.
 - (i) S-W A-100 Exterior Latex Low Sheen, A12 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - e. Topcoat: Latex, exterior, satin.
 - (i) S-W A-100 Exterior Latex Satin, A82 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - f. Topcoat: Latex, exterior, semi-gloss.
 - (i) S-W Solo Acrylic Semi-Gloss, A76 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - g. Topcoat: Latex, exterior, gloss.
 - (i) S-W A-100 Exterior Latex Gloss, A8 Series, at 4.0 mils wet, 1.3 mils dry, per coat.
 - 2. CMU Stain System (Water-Based):

- a. First Coat: Low-luster opaque finish matching topcoat.
 - b. Topcoat: Low-luster opaque finish.
 - (i) S-W H&C Colortop Water-Based Solid Color Concrete Stain, at 50 to 250 sq. ft. per gal. (1.23 to 6.14 sq. m per liter).
- D. Plastic Trim Fabrication Substrates: Including architectural PVC, plastic, and fiberglass items.
 - 1. Latex System:
 - a. Prime Coat: Primer, bonding, water-based:
 - (i) S-W PrepRite ProBlock Latex Primer/Sealer, B57-620 Series, at 4.0 mils wet, 1.4 mils dry.
 - b. Intermediate Coat: Latex, exterior, matching topcoat.
 - c. Topcoat: Latex, exterior, flat:
 - (i) S-W A-100 Exterior Latex Flat, A6 Series, at 4.0 mils wet, 1.2 mils dry, per coat.
 - d. Topcoat: Latex, exterior, low-sheen:
 - (i) S-W A-100 Exterior Latex Low Sheen, A12 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - e. Topcoat: Latex, exterior, satin:
 - (i) S-W A-100 Exterior Latex Satin, A82 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - f. Topcoat: Latex, exterior, semi-gloss:
 - (i) S-W Solo Acrylic Semi-Gloss, A76 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - g. Topcoat: Latex, exterior, gloss:
 - (i) S-W A-100 Exterior Latex Gloss, A8 Series, at 4.0 mils wet, 1.3 mils dry, per coat.
- E. Exterior Gypsum Board Substrates:
 - 1. Latex System:
 - a. Prime Coat: Primer bonding, water-based.
 - (i) S-W PrepRite ProBlock Latex Primer/Sealer, B57-620 Series, at 4.0 mils wet, 1.4 mils dry.
 - b. Intermediate Coat: Latex, exterior, matching topcoat.
 - c. Topcoat: Latex, exterior, flat.
 - (i) S-W A-100 Exterior Latex Flat, A6 Series, at 4.0 mils wet, 1.2 mils dry, per coat.
 - d. Topcoat: Latex, exterior, low-sheen.
 - (i) S-W A-100 Exterior Latex Low Sheen, A12 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - e. Topcoat: Latex, exterior, satin:
 - (i) S-W A-100 Exterior Latex Satin, A82 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - f. Topcoat: Latex, exterior, semi-gloss.

- (i) S-W Solo Acrylic Semi-Gloss, A76 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - g. Topcoat: Latex, exterior, gloss.
 - (i) S-W A-100 Exterior Latex Gloss, A8 Series, at 4.0 mils wet, 1.3 mils dry, per coat.
- F. Exterior Insulation Finish Systems (EIFS):
 - 1. Latex System:
 - a. First Coat: Latex, exterior, matching topcoat.
 - b. Topcoat: Latex, exterior flat.
 - (i) S-W A-100 Exterior Latex Flat, A6 Series, at 4.0 mils wet, 1.2 mil dry, per coat.
 - c. Topcoat: Latex, exterior, low-sheen:
 - (i) S-W A-100 Exterior Latex Low Sheen, A12 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - d. Topcoat: Latex, exterior, satin:
 - (i) S-W A-100 Exterior Latex Satin, A82 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - e. Topcoat: Latex, exterior, semi-gloss:
 - (i) S-W Solo Acrylic Semi-Gloss, A76 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - f. Topcoat: Latex, exterior, gloss:
 - (i) S-W A-100 Exterior Latex Gloss, A8 Series, at 4.0 mils wet, 1.3 mils dry, per cot.

3.07 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 09912

INTERIOR ARCHITECTURAL PAINTING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. Section includes surface preparation and the application of paint systems on interior substrates.
 - 1. Concrete.
 - 2. Clay masonry.
 - 3. Concrete masonry units (CMU).
 - 4. Steel.
 - 5. Cast iron.
 - 6. Galvanized metal.
 - 7. Aluminum (not anodized or otherwise coated).
 - 8. Wood.
 - 9. Gypsum board.
 - 10. Plaster.
 - 11. Spray-textured ceilings.
 - 12. Cotton or canvas insulation covering.
 - 13. ASJ insulation covering.
- B. Related Requirements:
 - 1. Section 09911 "Exterior Architectural Painting" for surface preparation and the application of paint systems on exterior substrates.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include preparation requirements and application instructions.
 - 1. Indicate VOC content.
- B. Sustainable Design Submittals:
 - 1. Product Data for LEED 2009 Credit EQ 4.2: For paints and coatings, showing printed statement of VOC content.
 - 2. Laboratory Test Reports: For paints and coatings, indicating compliance with LEED 2009 Credit EQ 4.2 requirements for low-emitting materials.
- C. Samples for Initial Selection: For each type of topcoat product.

- D. Samples for Verification: For each type of paint system and in each color and gloss of topcoat.
 - 1. Submit Samples on rigid backing, 8 inches square.
 - 2. Label each coat of each Sample.
 - 3. Label each Sample for location and application area.
- E. Product List: For each product indicated, include the following:
 - 1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
 - 2. Indicate VOC content.

1.04 CLOSEOUT SUBMITTALS

- A. Coating Maintenance Manual: Provide coating maintenance manual including area summary with finish schedule, area detail designating location where each product/color/finish was used, product data pages, material safety data sheets, care and cleaning instructions, touch-up procedures, and color samples of each color and finish used.

1.05 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Paint: 5 percent, but not less than 1 gal. of each material and color applied.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Delivery and Handling: Deliver products to Project site in an undamaged condition in manufacturer's original sealed containers, complete with labels and instructions for handling, storing, unpacking, protecting, and installing. Packaging shall bear the manufacturer's label with the following information:
 - 1. Product name and type (description).
 - 2. Batch date.
 - 3. Color number.
 - 4. VOC content.
 - 5. Environmental handling requirements.
 - 6. Surface preparation requirements.
 - 7. Application instructions.
- B. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.
 - 1. Maintain containers in clean condition, free of foreign materials and residue.
 - 2. Remove rags and waste from storage areas daily.

1.07 FIELD CONDITIONS

- A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F.
- B. Do not apply paints when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.
- C. Lead Paint: It is not expected that lead paint will be encountered in the Work.
 - 1. If suspected lead paint is encountered, do not disturb; immediately notify Architect and Owner.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Sherwin-Williams Company (The); products indicated or comparable product from one of the following:
 - 1. Benjamin Moore & Co.
 - 2. PPG Architectural Coatings.
 - 3. Pratt & Lambert.
 - 4. Valspar Corporation - Architectural (Pro).
- B. Comparable Products: Comparable products of approved manufacturers will be considered in accordance with Section 01600 "Materials and Equipment," and the following:
 - 1. Products are approved by manufacturer in writing for application specified.
 - 2. Products meet performance and physical characteristics of basis of design product including published ratio of solids by volume, plus or minus two percent.
- C. Source Limitations: Obtain paint materials from single source from single listed manufacturer.
 - 1. Manufacturer's designations listed on a separate color schedule are for color reference only and do not indicate prior approval.

2.02 PAINT, GENERAL

- A. Material Compatibility:
 - 1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 - 2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.
- B. VOC Content: For field applications that are inside the weatherproofing system, paints and coatings shall provide materials that comply with VOC limits of authorities having jurisdiction and for interior paints and coatings applied at Project site, the following VOC

limits exclusive of colorants added to a tint base, when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

1. Flat Paints and Coatings: 50 g/L.
2. Nonflat Paints and Coatings: 150 g/L.
3. Primers, Sealers, and Undercoaters: 200 g/L.
4. Anticorrosive and Antirust Paints Applied to Ferrous Metals: 250 g/L.
5. Floor Coatings: 100 g/L.
6. Shellacs, Clear: 730 g/L.
7. Shellacs, Pigmented: 550 g/L.

C. Low-Emitting Materials: Interior paints and coatings shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small Scale Environmental Chambers."

D. Colors: As selected by Architect from manufacturer's full range.

1. 20 percent of surface area will be painted with deep tones.

2.03 SOURCE QUALITY CONTROL

- A. Testing of Paint Materials: Owner reserves the right to invoke the following procedure:
1. Owner will engage the services of a qualified testing agency to sample paint materials. Contractor will be notified in advance and may be present when samples are taken. If paint materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
 2. Testing agency will perform tests for compliance with product requirements.
 3. Owner may direct Contractor to stop applying coatings if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying paint materials from Project site, pay for testing, and repaint surfaces painted with rejected materials. Contractor will be required to remove rejected materials from previously painted surfaces if, on repainting with complying materials, the two paints are incompatible.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers. Where acceptability of substrate conditions is in question, apply samples and perform in-situ testing to verify compatibility, adhesion, and film integrity of new paint application.

1. Report, in writing, conditions that may affect application, appearance, or performance of paint.

B. Substrate Conditions:

1. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
 - a. Concrete: 12 percent.
 - b. Masonry (Clay and CMU): 12 percent.
 - c. Wood: 15 percent.
 - d. Gypsum Board: 12 percent.
 - e. Plaster: 12 percent.
 2. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.
 3. Plaster Substrates: Verify that plaster is fully cured.
 4. Spray-Textured Ceiling Substrates: Verify that surfaces are dry.
- C. Proceed with coating application only after unsatisfactory conditions have been corrected; application of coating indicates acceptance of surfaces and conditions.
- 3.02 PREPARATION
- A. Comply with manufacturer's written instructions and recommendations in "MPI Manual" applicable to substrates indicated.
 - B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
 1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.
 - C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
 1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.
 - D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.
 1. Concrete Floors: Remove oil, dust, grease, dirt, and other foreign materials. Comply with SSPC-SP-13/NACE 6 or ICRI 03732.
 - E. Masonry Substrates: Remove efflorescence and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces or mortar joints exceed that permitted in manufacturer's written instructions.
 - F. Steel Substrates: Remove rust, loose mill scale, and shop primer, if any. Clean using methods recommended in writing by paint manufacturer but not less than the following:
 1. SSPC-SP 2, "Hand Tool Cleaning."
 2. SSPC-SP 3, "Power Tool Cleaning."
 3. SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
 4. SSPC-SP 11, "Power Tool Cleaning to Bare Metal."

- G. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.
- H. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal fabricated from coil stock by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.
- I. Aluminum Substrates: Remove loose surface oxidation.
- J. Wood Substrates:
 - 1. Scrape and clean knots, and apply coat of knot sealer before applying primer.
 - 2. Sand surfaces that will be exposed to view, and dust off.
 - 3. Prime edges, ends, faces, undersides, and backsides of wood.
 - 4. After priming, fill holes and imperfections in the finish surfaces with putty or plastic wood filler. Sand smooth when dried.
- K. Cotton or Canvas Insulation Covering Substrates: Remove dust, dirt, and other foreign material that might impair bond of paints to substrates.

3.03 APPLICATION

- A. Apply paints according to manufacturer's written instructions and to recommendations in "MPI Manual."
 - 1. Use applicators and techniques suited for paint and substrate indicated.
 - 2. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
 - 3. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
 - 4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
 - 5. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.
- B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Tint undercoats to match color of topcoat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.
- C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.
- D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
- E. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:
 - 1. Paint the following work where exposed in equipment rooms:

- a. Equipment, including panelboards and switch gear.
 - b. Uninsulated metal piping.
 - c. Uninsulated plastic piping.
 - d. Pipe hangers and supports.
 - e. Metal conduit.
 - f. Plastic conduit.
 - g. Tanks that do not have factory-applied final finishes.
 - h. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
2. Paint the following work where exposed in occupied spaces:
- a. Equipment, including panelboards.
 - b. Uninsulated metal piping.
 - c. Uninsulated plastic piping.
 - d. Pipe hangers and supports.
 - e. Metal conduit.
 - f. Plastic conduit.
 - g. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
 - h. Other items as directed by Architect.
3. Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that are visible from occupied spaces.

3.04 FIELD QUALITY CONTROL

- A. Dry Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry film thickness.
- 1. Contractor shall touch up and restore painted surfaces damaged by testing.
 - 2. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written recommendations.

3.05 CLEANING AND PROTECTION

- A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
- B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
- C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.
- D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.06 INTERIOR MICROBICIDAL PAINTING SCHEDULE

- A. Concrete Substrates, Nontraffic Surfaces and Clay Masonry:
 - 1. Microbical Latex Finish System: With topcoat EPA registered No. 64695-1.
 - a. Prime Coat: Primer sealer, latex, interior:
 - (i) S-W Loxon Concrete & Masonry Primer Sealer, A24W8300, at 8.0 mils wet, 3.2 mils dry.
 - b. First Coat: Microbical Latex, interior, matching topcoat.
 - c. Topcoat: Microbical Latex, interior, eggshell:
 - (i) S-W Paint Shield Interior Latex Eg-Shel Microbical Paint, D12W51, at 4.0 mils wet, 1.8 mils dry, per coat. Brush and roll application only.
- B. CMU Substrates:
 - 1. Microbical Latex Finish System: With topcoat EPA registered No. 64695-1.
 - a. Block Filler: One or two coats as required: Block filler, latex, interior/exterior:
 - (i) S-W Loxon Block Surfacer, A24W200, at 10.0 mils wet, 8.0 mils dry, per coat.
 - b. First Coat: Microbical Latex, interior, matching topcoat.
 - c. Topcoat: Microbical Latex, interior, eggshell:
 - (i) S-W Paint Shield Interior Latex Eg-Shel Microbical Paint, D12W51, at 4.0 mils wet, 1.6 mils dry, per coat. Brush and roll application only.
- C. Gypsum Board, Plaster, and Spray-Texture Ceiling Substrates:
 - 1. Microbical Latex Finish System: With topcoat EPA registered No. 64695-1.
 - a. Prime Coat: Primer, latex, interior:
 - (i) S-W ProMar 200 Zero VOC Latex Primer, B28W2600, at 4.0 mils wet, 1.0 mils dry.
 - b. First Coat: Microbical Latex, interior, matching topcoat.
 - c. Topcoat: Microbical Latex, interior, eggshell:
 - (i) S-W Paint Shield Interior Latex Eg-Shel Microbical Paint, D12W51, at 4.0 mils wet, 1.8 mils dry, per coat. Brush and roll application only.

3.07 INTERIOR PAINTING SCHEDULE

- A. Concrete Substrates, Nontraffic Surfaces and Clay Masonry:
 - 1. Latex System:
 - a. Prime Coat: Primer, latex, interior.
 - (i) S-W Loxon Concrete & Masonry Primer Sealer, A24W8300, at 8.0 mils wet, 3.2 mils dry.
 - b. Intermediate Coat: Latex, interior, matching topcoat.
 - c. Topcoat: Latex, interior, flat.
 - (i) S-W ProMar 200 Zero VOC Latex Flat, B30-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat.
 - d. Topcoat: Latex, interior, low sheen.

- (i) S-W ProMar 200 Zero VOC Latex Low Sheen Eg-Shel, B24-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat.
 - e. Topcoat: Latex, interior, eggshell.
 - (i) S-W ProMar 200 Zero VOC Latex Eg-Shel, B20-2600 Series, at 4.0 mils wet, 1.7 mils dry, per coat .
 - f. Topcoat: Latex, interior, semi-gloss.
 - (i) S-W ProMar 200 Zero VOC Latex Semi-Gloss, B31-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat .
 - g. Topcoat: Latex, interior, gloss.
 - (i) S-W ProMar 200 Zero VOC Gloss, B21-12650 Series, at 4.0 mils wet, 1.4 mils dry, per coat.
 - 2. Water-Based Light Industrial Coating System:
 - a. Prime Coat: Primer sealer, latex, interior:
 - (i) S-W Loxon Concrete & Masonry Primer Sealer, A24W8300, at 8.0 mils wet, 3.2 mils dry.
 - b. Intermediate Coat: Light industrial coating, interior, water based, matching topcoat.
 - c. Topcoat: Light industrial coating, interior, water based, eggshell:
 - (i) S-W Pro Industrial Pre-Catalyzed Water Based Epoxy, K45-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - d. Topcoat: Light industrial coating, interior, water based, semi-gloss:
 - (i) S-W Pro Industrial Pre-Catalyzed Water Based Epoxy, K46-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - 3. Two-Component Epoxy and Epoxy High Build Systems for Non-Traffic Surfaces: Refer to Section 09960 "High-Performance Coatings."
 - 4. Concrete Stain System (Water-based) for Vertical Surfaces:
 - a. First Coat:
 - (i) S-W H&C Colortop Water-Based Solid Color Concrete Stain, at 50 to 300 sq. ft. per gal.
 - b. Second Coat:
 - (i) S-W H&C Colortop Water-Based Solid Color Concrete Stain, at 50 to 300 sq. ft. per gal.
- B. Concrete Substrates, Pedestrian Traffic Surfaces:
- 1. Latex Floor Enamel System:
 - a. First Coat: Floor paint, latex, slip-resistant, matching topcoat.
 - b. Topcoat: Floor paint, latex, slip-resistant, low gloss: S-W ArmorSeal Tread-Plex, B90 Series, at 1.5 to 2.0 mils dry per coat.
 - 2. Clear Acrylic System, Gloss Finish:
 - a. First Coat:
 - (i) S-W H&C Clarishield Water-Based Wet-Look Concrete Sealer, at 100 to 200 sq. ft. per gal.
 - b. Second Coat:

- (i) S-W H&C Clarishield Water-Based Wet-Look Concrete Sealer, at 100 to 200 sq. ft. per gal.
 - 3. Concrete Stain System (Water-based):
 - a. First Coat: Low-luster opaque finish:
 - (i) S-W H&C Colortop Water-Based Solid Color Concrete Stain, at 50 to 300 sq. ft. per gal.
 - b. Second Coat: Low-luster opaque finish:
 - (i) S-W H&C Colortop Water-Based Solid Color Concrete Stain, at 50 to 300 sq. ft. per gal.
 - 4. Epoxy and Urethane Coatings: Refer to Section 09960 "High-Performance Coatings."
- C. CMU Substrates:
 - 1. Latex System:
 - a. Block Filler: Block filler, latex, interior/exterior:
 - (i) S-W PrepRite Block Filler, B25W25, at 75-125 sq. ft. per gal.
 - b. Intermediate Coat: Latex, interior, matching topcoat.
 - c. Topcoat: Latex, interior, flat:
 - (i) S-W ProMar 200 Zero VOC Latex Flat, B30-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat.
 - d. Topcoat: Latex, interior, low sheen:
 - (i) S-W ProMar 200 Zero VOC Latex Low Sheen Enamel, B24-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat.
 - e. Topcoat: Latex, interior, eggshell:
 - (i) S-W ProMar 200 Zero VOC Latex Eg-Shel, B20-2600 Series, at 4.0 mils wet, 1.7 mils dry, per coat.
 - f. Topcoat: Latex, interior, semi-gloss:
 - (i) S-W ProMar 200 Zero VOC Latex Semi-Gloss, B31-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat.
 - g. Topcoat: Latex, interior, gloss:
 - (i) S-W ProMar 200 Zero VOC Gloss, B21-12650 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - 2. Water-Based Light Industrial Coating System:
 - a. Block Filler: Block filler, latex, interior/exterior:
 - (i) S-W PrepRite Block Filler, B25W25, at 75-125 sq. ft. per gal.
 - b. Intermediate Coat: Light industrial coating, interior, water based, matching topcoat.
 - c. Topcoat: Light industrial coating, interior, water based, eggshell:
 - (i) S-W Pro Industrial Pre-Catalyzed Water Based Epoxy, K45-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - d. Topcoat: Light industrial coating, interior, water based, semi-gloss:
 - (i) S-W Pro Industrial Pre-Catalyzed Water Based Epoxy, K46-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - 3. Concrete Stain System (Water-based):

- a. First Coat:
 - (i) S-W H&C Colortop Water-Based Solid Color Concrete Stain, at 50 to 300 sq. ft. per gal.
 - 4. Second Coat:
 - (i) S-W H&C Colortop Water-Based Solid Color Concrete Stain, at 50 to 300 sq. ft. per gal.
 - (a) Two-Component Epoxy and Epoxy High Build Systems for Non-Traffic Surfaces: Refer to Section 09960 "High-Performance Coatings."
 - (b) Epoxy and Urethane Coatings: Refer to Section 09960 "High-Performance Coatings."
- D. Metal Substrates (Aluminum, Steel, Galvanized Steel):
- 1. Latex System:
 - a. Prime Coat: Primer, rust-inhibitive, water based:
 - (i) S-W Pro Industrial Pro-Cryl Universal Primer, B66-310 Series, at 5.0 to 10 mils wet, 2.0 to 4.0 mils dry.
 - b. Intermediate Coat: Water-based acrylic, interior, matching topcoat.
 - c. Topcoat: Water-based acrylic, semi-gloss:
 - (i) S-W Pro Industrial Acrylic Semi-Gloss Coating, B66-650 Series, at 2.5 to 4.0 mils dry, per coat.
 - d. Topcoat: Water-based acrylic, gloss:
 - (i) S-W Pro Industrial Acrylic Gloss Coating, B66-660 Series, at 2.5 to 4.0 mils dry, per coat.
 - 2. Water-Based Dry-Fall System:
 - a. Top Coat: Dry-fall latex, flat:
 - (i) S-W Pro Industrial Waterborne Acrylic Dryfall Flat, B42-181 Series, at 6.0 mils wet, 1.5 mils dry.
 - b. Top Coat: Dry-fall latex, eggshell:
 - (i) S-W Pro Industrial Waterborne Acrylic DryFall Eg-Shel, B42-82, at 6.0 mils wet, 1.9 mils dry.
 - c. Top Coat: Dry-fall latex, semi-gloss:
 - (i) S-W Pro Industrial Waterborne Acrylic DryFall Semi-Gloss, B42-83, at 5.8 mils wet, 2.3 mils dry.
 - 3. Water-Based Light Industrial Coating System:
 - a. Prime Coat: Primer, rust-inhibitive, water based:
 - (i) S-W Pro Industrial Pro-Cryl Universal Primer, B66-310 Series, at 5.0 to 10 mils wet, 2.0 to 4.0 mils dry.
 - b. Intermediate Coat: Light industrial coating, interior, water based, matching topcoat.
 - c. Topcoat: Light industrial coating, interior, water based, eggshell:
 - (i) S-W Pro Industrial Pre-Catalyzed Water Based Epoxy, K45-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - d. Topcoat: Light industrial coating, interior, water based, semi-gloss:

- (i) S-W Pro Industrial Pre-Catalyzed Water Based Epoxy, K46-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - 4. Two-Component Epoxy and Epoxy High Build Systems: Refer to Section 09960 "High-Performance Coatings."
 - 5. Waterbased/Alkyd Urethane System:
 - a. Prime Coat:
 - (i) S-W Pro Industrial Pro-Cryl Universal Primer, B66-310 Series, at 5.0 to 10 mils wet, 2.0 to 4.0 mils dry.
 - b. Intermediate Coat: Water-based acrylic-alkyd, interior, matching topcoat.
 - c. Topcoat: Water-based alkyd-urethane, semi-gloss, interior:
 - (i) S-W Pro Industrial Waterbased Alkyd Urethane Semi-Gloss, B53-1150 Series, at 4.0 mils wet, 1.4 mils dry, per coat.
 - d. Topcoat: Water-based alkyd-urethane, gloss, interior:
 - (i) S-W Pro Industrial Waterbased Alkyd Urethane Gloss, B53-1050 Series, at 4.0 mils wet, 1.4 mils dry, per coat.
- E. Gypsum Board, Plaster, and Spray-Texture Ceiling Substrates:
 - 1. Latex System:
 - a. Prime Coat: Primer, latex, interior:
 - (i) S-W ProMar 200 Zero VOC Latex Primer, B28W2600, at 4.0 mils wet, 1.0 mils dry.
 - b. Intermediate Coat: Latex, interior, matching topcoat.
 - c. Topcoat: Latex, interior, flat:
 - (i) S-W ProMar 200 Zero VOC Latex Flat, B30-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat.
 - d. Topcoat: Latex, interior, low sheen:
 - (i) S-W ProMar 200 Zero VOC Latex Low Sheen Enamel, B24-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat.
 - e. Topcoat: Latex, interior, eggshell:
 - (i) S-W ProMar 200 Zero VOC Latex Eg-Shel, B20-2600 Series, at 4.0 mils wet, 1.7 mils dry, per coat.
 - f. Topcoat: Latex, interior, semi-gloss:
 - (i) S-W ProMar 200 Zero VOC Latex Semi-Gloss, B31-2600 Series, at 4.0 mils wet, 1.6 mils dry, per coat.
 - g. Topcoat: Latex, interior, gloss:
 - (i) S-W ProMar 200 Zero VOC Gloss, B21-12650 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - 2. Water-Based Light Industrial Coating System:
 - a. Prime Coat: Primer sealer, latex, interior:
 - (i) S-W ProMar 200 Zero VOC Latex Primer, B28W2600, at 4.0 mils wet, 1.0 mils dry.
 - b. Intermediate Coat: Light industrial coating, interior, water based, matching topcoat.
 - c. Topcoat: Light industrial coating, interior, water based, eggshell:

- (i) S-W Pro Industrial Pre-Catalyzed Waterbased Epoxy, K45-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
 - d. Topcoat: Light industrial coating, interior, water based, semi-gloss:
 - (i) S-W Pro Industrial Pre-Catalyzed Waterbased Epoxy, K46-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat.
- 3. Two-Component Epoxy and Epoxy High Build Systems for Non-Traffic Surfaces:
Refer to Section 09960 "High-Performance Coatings."

3.08 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 11000
EQUIPMENT GENERAL PROVISIONS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The CONTRACTOR shall provide all tools, supplies, materials, equipment, and all labor necessary for the furnishing, construction, installation, testing, and operation of all equipment and appurtenant Work, complete and operable, all in accordance with the requirements of the Contract Documents.
- B. The provisions herein will apply to all equipment specified and where referred to, except where otherwise specified or shown.
- C. In case of conflict between this Section and the individual equipment specification section, the more stringent requirements shall govern.
- D. In case of conflict between this Section and Section 00700 – General Conditions, Section 00700 – General Conditions will take precedence.

1.02 SUBMITTALS

- A. Shop Drawings: The CONTRACTOR shall furnish complete shop drawings for all equipment specified in the various Sections, together with all piping, valves, and controls for review by the ENGINEER in accordance with Section 01300 – Submittals.
 - 1. Drawings showing general dimensions and conforming the size of equipment, drives and specified appurtenances, piping connections and construction details of equipment.
 - 2. Assembly and installation drawings including shaft size, seal, coupling, bearings, anchor bolt plan, part nomenclature, part list with materials of construction by ASTM reference and grade, outline dimensions, and shipping weights.
 - 3. Submit methods and criteria used for calculating equipment anchorage forces and the capacities of the anchorage elements.
 - 4. Manufacturer's installation instructions.
 - 5. Data, in accordance with Division 16 – Electrical for the electric motors, proposed for each equipment.
 - 6. Variable speed drive information as required under Division 16 – Electrical.
 - 7. Elevations of proposed Local Control Panel showing panel-mounted devices, details of enclosure type, single line diagram of power distribution, and current draw of panel, and list of all terminals required to receive inputs or to transmit outputs from the Local Control Panel.
 - 8. Wiring diagrams of field connections with identification of terminations between Local Control Panels, junction terminal boxes, and equipment items.
 - 9. Complete electrical schematic diagrams.
 - 10. Complete description and sketch of proposed test setup for factory test if a factory test is required by the requirements herein or the individual equipment section at

least 60 days prior to proposed test date. Submittal material shall include sample calculations and proposed test log format.

11. Factory Test Data: Signed, dated, and certified factory test data for each equipment system which requires factory testing, submitted four weeks prior to shipment of equipment.

B. Certifications

1. A Certificate of Unit Responsibility Assignment signed by officers of both the CONTRACTOR and the Equipment Manufacturer Corporations, attesting to the assignment of responsibility in accordance with these Contract Documents. No other submittal material will be reviewed until the certificate has been submitted and found to be in conformance with these requirements.
2. If factory tests are required by these Specifications, submit certification of satisfactory testing of each equipment unit as specified. The certified material shall include copies of test logs and resulting performance results at least four weeks prior to shipping the units from the factory. Submit certified calibration test results on all instruments used for conducting the factory tests.
3. Manufacturers' certification of proper installation.
4. Satisfactory field testing certification of the equipment units.

C. Owner's Manual: Submit Operation and Maintenance manual in accordance with Section 01730 – Operation and Maintenance Data. Operation and Maintenance manuals shall include data for each equipment unit, including motor. The Owner's shall contain following:

1. Manufacturer's written guarantee that equipment operates within the requirements specified in the Contract Documents.
2. If factory tests are required by these Specifications, certified copies of test logs and resulting performance results shall be included in the manual. Certified calibration test results on all instruments used for conducting the factory tests shall also be included in the manual.
3. Vibration and noise measurement results.
4. Include in Owner's Manual the procedures for shutting down and locking out all mechanical and electrical items that store or move hazardous energy when maintenance is required. Procedure should be as simple as possible.

1.03 REFERENCE STANDARDS

A. Except as otherwise indicated, the applicable standards of the following organizations apply to the Work of this Section:

1. American Society for Testing and Materials (ASTM).
2. American Public Health Association (APHA).
3. American National Standards Institute (ANSI).
4. American Society of Mechanical Engineers (ASME).
5. American Water Works Association (AWWA).
6. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).
7. American Welding Society (AWS).

8. National Fire Protection Association (NFPA).
9. Rubber Manufacturers Association (RMA).
10. National Electrical Manufacturers Association (NEMA).
11. Antifriction Bearing Manufacturers Association (AFBMA).
12. American Gear Manufacturers Association (AGMA).
13. Federal Specifications (FS).
14. Manufacturer's published recommendations and specifications.
15. Occupational Safety and Health Administration (OSHA).

B. The following standards apply to the Work of this Section:

ASME B1.20.1	General Purpose Pipe Threads (Inch)
ASME B16.1	Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.5	Pipe Flanges and Flanged Fittings, NPS ½ Through NPS 24 Metric/Inch Standard
ASME B31.1	Power Piping
ASME B46.1	Surface Texture
ANSI/AWWA C206	Field Welding of Steel Water Pipe
ANSI/AWWA C207	Steel Pipe Flanges for Waterworks Service – Sizes 4 in. Through 144 in.
ANSI/ASA S12.6	Method for the Measurement of the Real-Ear Attenuation of Hearing Protectors
ASTM A 48	Specification for Gray Iron Castings
ASTM A 108	Specification for Steel Bars, Carbon, and Alloy Cold-Finished

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications

Unless otherwise acceptable to the ENGINEER, all equipment furnished shall have a record of at least 10 years of successful, trouble-free operation in similar applications, from the same Manufacturer.

B. Services of Manufacturer's Representative

Inspection, Start-Up, and Field Adjustment: The CONTRACTOR shall demonstrate that all equipment meets the specified performance requirements. The CONTRACTOR shall provide the services of an experienced, competent, and authorized service representative of the Manufacturer of each item of major equipment who shall visit the site of Work to perform the following tasks:

1. Assist the CONTRACTOR in the installation of the equipment.
2. To inspect, check, adjust if necessary and approve the equipment installation.
3. To Start-Up and field-test the equipment for proper operation, efficiency, and capacity.
4. To perform necessary field adjustments during the test period until the equipment installation and operation are satisfactory to the ENGINEER.
5. Provide agenda for operation and maintenance training to the OWNER's Representative.
6. Instruction of the OWNER's Personnel:
 - a. Where required by the individual equipment sections, an authorized training representative of the Manufacturer shall visit the Site for the number of days indicated in those sections to instruct the OWNER's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with necessary test equipment. Instruction shall be specific to the models of equipment provided.
 - b. The representative shall have at least 2 years of experience in training. A resume of the representative shall be submitted.
 - c. Training shall be scheduled 3 weeks in advance of the scheduled session.
 - d. Proposed training material and a detailed outline of each lesson shall be submitted for review. Review comments from the ENGINEER shall be incorporated into the material.
 - e. The training materials shall remain with the trainees after the session.
 - f. The OWNER will videotape in DVD format the training for later use by the OWNER's personnel.
7. Costs: The costs of all inspection, Start-Up, testing, adjustment, and instruction Work performed by factory-trained representatives at the site shall be borne by the CONTRACTOR. When available, the OWNER's operating personnel will provide assistance in the field-testing.

- C. Inspection: It shall be the responsibility of the CONTRACTOR to inform the local authorities, such as building and plumbing inspectors, Fire Marshall, OSHA inspectors, and others, to witness all required tests for piping, plumbing, fire protection systems, pressure vessels, safety systems, etc., to obtain all required permits and certificates, and pay all fees.

1.05 UNIT RESPONSIBILITY

- A. Equipment systems made up of two or more components shall be provided as a single unit by the Manufacturer of the primary driven equipment. The Manufacturer of the primary driven equipment shall assume the unit responsibility. Unless otherwise indicated, the CONTRACTOR shall cause each system component to be furnished by the Manufacturer with unit responsibility. The extent of the Manufacturer's responsibilities shall include engineering the specified equipment, preparation of all submittals materials, coordinating manufacture and procurement process, compatibility and shipment of all specified components, design of all equipment support, providing installation and testing to assist the CONTRACTOR in completing the installation and commissioning the equipment, furnishing factory trained certified specialists to train the

OWNER's staff, and the production and submission of specified Operation and Maintenance Manuals. The CONTRACTOR is responsible to the OWNER for performance of all systems as indicated. The CONTRACTOR shall ensure that the submittal of a Certificate of Unit Responsibility signed by the Manufacturer with unit responsibility.

1.06 DELIVERY, HANDLING AND STORAGE

- A. The equipment Manufacturer shall provide unloading, storage, and handling instructions to the CONTRACTOR prior to shipment.
- B. Equipment delivered onsite without an accepted submittal will not be allowed to be unloaded.
- C. Equipment shall be boxed, crated, or otherwise protected from damage and moisture during shipment, handling, and storage. Equipment shall be protected from exposure to corrosive fumes and shall be kept thoroughly dry at all times. Pumps, motors, drives, electrical equipment, and other equipment with anti-friction or sleeve bearings shall be stored in weather tight storage facilities prior to installation. For extended storage periods, plastic equipment wrappers shall not be used to prevent accumulation of condensate in gears and bearings, and rotating equipment rotated per Manufacturer requirements.
- D. All equipment shall be delivered to the CONTRACTOR in good, sound condition, and free from damage. Equipment which has been damaged will be rejected. Equipment Manufacturer's representative shall be on the site to witness the arrival, inspection, and unloading process if specified in individual specification section.
- E. The CONTRACTOR shall be responsible for proper unloading, handling, and storage of all equipment in accordance with the Manufacturer's instructions. Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.

1.07 MAINTENANCE/SPARE PARTS

- A. Tools: The CONTRACTOR shall supply one complete set of special wrenches and other special tools necessary for the assembly, adjustment, and dismantling of the equipment. All tools shall be of best quality hardened steel forgings with bright finish; wrench heads shall have work faces dressed to fit nuts. All tools shall be suitable for professional work and manufactured by a recognized supplier of professional tools such as Snap On, Crescent, Stanley, or equal. The set of tools shall be neatly mounted in a labeled tool box of suitable design provided with a lockable hinged cover.
- B. Spare Parts: All equipment shall be furnished with the Manufacturer's recommended spare parts as indicated in the individual equipment Sections. The CONTRACTOR shall also obtain and submit from the Manufacturer a list of suggested spare parts for each piece of equipment. The CONTRACTOR shall also furnish the name, address, and telephone number of the nearest distributor for each piece of equipment. Spare parts shall be tagged by project equipment number and identified as to part number, equipment Manufacturer, and subassembly component. Spare parts subject to deterioration such as ferrous metal items and electrical components shall be properly

protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than 2 feet wide, or 18 inches high, or 3 feet in length shall be stored in a wooden box with hinged wooden cover and locking hasp. Hinge shall be strap type. The box shall be painted and identified with stenciled lettering stating the name of the equipment, equipment numbers, and word "spare parts". A neatly typed inventory of spare parts shall be taped to the underside of the cover. All spare parts are intended for use by the OWNER only, after expiration of the warranty period specified in the Contract Documents.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Noise Level: When in operation, no piece of equipment shall exceed the OSHA noise level requirements for one hour exposure.
 - 1. High Noise Level Location: The CONTRACTOR shall provide three personal hearing protection and storage cabinet, as specified herein, at each high noise level location. This requirement shall not relieve the CONTRACTOR from meeting noise level requirements specified in the Contract Documents. The high noise level locations are defined as follows:
 - a. Outdoor Location: Any single equipment item or any group of equipment items that produce noise exceeding OSHA noise level requirements for a 2-hour exposure of 100 dBA. Where such equipment is separated by a distance of more than 20 feet, measured between edges of footings, each group of equipment shall be provided with a separate hearing protection station.
 - b. Indoor Location:
 - i. Any single equipment item, or any group of items, located within a single room normally occupied, that produces noise exceeding OSHA noise level requirements for a 2-hour exposure.
 - ii. Any single equipment item, or any group of items, located within a single room normally occupied by workers that produces noise exceeding OSHA noise level requirements for 8-hour exposure.
- B. Personal Hearing Protection: The CONTRACTOR shall supply, in their original unopened packaging, three pairs of high attenuation hearing protectors at each high noise location. The ear protectors shall be capable of meeting the requirements of ANSI/ASA S12.6 and shall produce a noise level reduction of 25 dBA at a frequency of 500 Hz. The hearing protectors shall have fluid filled ear cushions and an adjustable, padded headband. The protectors shall be stored in a weatherproof, labeled, steel cabinet, furnished by the CONTRACTOR and mounted in an approved location near the noise producing equipment.
- C. Drive Trains and Service Factors: Service factors shall be applied in the selection or design of mechanical power transmission components in accordance with AGMA. Components of drive train assemblies between the prime mover and the driven equipment shall be designed and rated to deliver the maximum peak or starting torque, speed, and horsepower. All of the applicable service factors shall be considered, such

as mechanical (type of prime mover), load class, start frequency, ventilation, ambient temperature, and fan factors. Drive train components include couplings, shafts, gears and gear drives, drive chains, sprockets, and V-belt drives.

- D. Dissimilar Materials: For incompatible dissimilar metals, CONTRACTOR shall include dielectric kits to prevent corrosion between dissimilar metals / materials.
- E. For thermal rating adjustments such as start frequency, ambient temperature, and hourly duty cycle factor, ventilation factor, and fan factor, refer to gear Manufacturer sizing information.
- F. For service factors of electric motors, see Section 16150 – NEMA Frame Induction Motors, 600V and Below.
- G. Where load classifications are not indicated, service factors shall be for standard load classifications and for flexible couplings.
- H. Welding: Unless otherwise specified or shown, all welding shall conform to the following:
 - 1. Latest revision of applicable AWS Welding Code
 - 2. Latest revision of ANSI/AWWA C206.
 - 3. All composite fabricated steel assemblies which are to be erected or installed inside a hydraulic structure, including any fixed or movable structural components of mechanical equipment, shall have continuous seal welds to prevent entrance of air or moisture.
 - 4. All welding shall be by the metal-arc method or gas-shielded arc method as described in the American Welding Society's "Welding Handbook" as supplemented by other pertinent standards of the AWS. Qualification of welders shall be in accordance with the AWS Standards governing same. Submit welders' qualifications.
 - 5. In assembly and during welding, the component parts shall be adequately clamped, supported, and restrained to minimize distortion and for control of dimensions. Weld reinforcement shall be as specified by the AWS code. Upon completion of welding, all weld splatter, flux, slag, and burrs left by attachments shall be removed. Welds shall be repaired to produce a workmanlike appearance, with uniform weld contours and dimensions. All sharp corners of material which is to be painted or coated shall be ground to a minimum of 1/32-inch on the flat.
- I. Protective Coating: All equipment shall be painted or coated in accordance with Division 9 - Finishes, unless otherwise indicated. Non-ferrous metal and corrosion resisting steel surfaces shall be coated with grease or lubricating oil. Coated surfaces shall be protected from abrasion or other damage during handling, testing, storing, assembly, and shipping.
- J. Identification of Equipment Items: Each item of equipment shipped shall have an indelible, legible identifying mark corresponding to the equipment number shown or specified for the particular item.
- K. Vibration Level: All equipment subject to vibration shall be provided with restrained spring-type vibration isolators or pads per Manufacturer's written recommendations.

- L. Shop Fabrication: Shop fabrication shall be performed in accordance with the Contract Documents and the ENGINEER's accepted shop drawings. Fabrication prior to accepted shop drawings will be at the CONTRACTOR's risk.
- M. Tolerances: Tolerances and clearances shall be as shown on the shop drawings and shall be closely adhered to. Machine work shall in all cases be of high-grade workmanship and finish, with due consideration to the special nature or function of the parts. Members without milled ends and which are to be framed to other steel parts of the structure may have a variation in the detailed length of not greater than 1/16-inch for members 30 feet or less in length, and not greater than 1/8-inch for members over 30 feet in length.
- N. Castings: Castings shall be homogenous and free from non-metallic inclusions and defects. Surfaces of castings which are not machined shall be cleaned to remove foundry irregularities. Casting defects not exceeding 12.5 percent of the total thickness and where defects will not affect the strength and serviceability of the casting may be repaired by approved welding procedures. The ENGINEER shall be notified of larger defects. No repair welding of such defects shall be carried out without the ENGINEER's written approval. If the removal of metal for repair reduces the stress resisting cross-section of the casting by more than 25 percent or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 percent, then the casting may be rejected. Costs of casting new material shall be the CONTRACTOR's responsibility as part of the Work.
- O. Machine Finish: The type of finish shall be the most suitable for the application and shall be shown in micro-inches in accordance with ANSI B46.1. The following finishes shall be used:
 - 1. Surface roughness not greater than 63 micro-inches shall be required for all surfaces in sliding contact.
 - 2. Surface roughness shall not exceed 250 micro-inches except where a tight joint is indicated.
 - 3. Rough finish not greater than 500 micro-inches shall be required for other machined surfaces.
 - 4. Contact surfaces of shafts and stems which pass through stuffing boxes and contact surfaces of bearings shall be finished to not greater than 32 micro-inches.

2.02 EQUIPMENT SUPPORTS AND FOUNDATIONS

- A. Equipment Supports: All equipment supports, anchors, and restrainers shall be adequately designed for static, dynamic, wind, and seismic loads. The design horizontal seismic force shall be the greater of: that noted in the general structural notes or as required by the governing building code, or 10 percent of gravity. Submitted design calculations for equipment supports must bear the signature and seal of an Engineer licensed in the State where the Project is to be built, unless otherwise indicated. Calculations shall account for forces and distribution of forces on supporting structures resulting from normal operation, normal operation plus seismic loadings, and normal operation plus wind loadings.

1. Wall-mounted equipment weighing more than 250 pounds or which is within 18-inches above the floor shall be provided with fabricated stainless steel supports. Pedestals shall be of welded stainless steel. If the supported equipment is a panel or cabinet or is enclosed with removable sides, the pedestal shall match the supported equipment in appearance and dimensions.
 2. Seismic requirements: Freestanding and wall-hung equipment shall be anchored in place by methods that satisfy the building code. Calculations shall be performed and signed and stamped for equipment weighing more than 400 pounds. Calculations shall analyze lateral and overturning forces and meet all applicable building code requirements. Calculations shall include the distribution of forces imposed on the supporting structure and anchors, verifying that each anchor can develop the required resistance forces.
 3. Wind requirements: Exterior freestanding equipment shall be anchored in place by methods that satisfy the building code. Calculations shall be performed and signed and stamped, analyzing lateral and overturning forces and meet all applicable building code requirements. Calculations shall include the distribution of forces imposed on the supporting structure and anchors, verifying that each anchor can develop the required resistance forces.
- B. Anchors: Anchor bolts shall be in accordance with Division 5 – Metals and all Manufacturer’s recommendations. In the event that requirements are conflicting, the more stringent requirements shall apply. The CONTRACTOR shall determine the size, type, capacity, location and other placement requirements of anchorage elements. Anchoring methods and leveling criteria shall be followed as per Manufacturer’s literature.
- C. Equipment Foundations: Equipment foundations shall be as shown in the Drawings and in accordance with Manufacturer’s written recommendations. In the event that requirements are conflicting, the more stringent requirements shall apply. All mechanical equipment, tanks, control cabinets, etc., shall be supported as shown in the Drawings, unless otherwise specified.

2.03 PIPE HANGERS, SUPPORTS, AND GUIDES

- A. All pipe connections to equipment shall be supported, anchored, and guided to minimize stresses and loads on equipment flanges and equipment. Supports and hangers shall comply with the requirements of Section 15140 – Supports and Hangers.

2.04 FLANGES AND PIPE THREADS

- A. All flanges on equipment and appurtenances provided herein shall conform to ASME B16.1, Class 125; or B16.5, Class 150, unless otherwise shown. All pipe threads shall be in accordance with ASME B1.20.1.

2.05 COUPLINGS

- A. Flexible couplings shall be provided between the driver and the driven equipment to accommodate slight angular misalignment, parallel misalignment, end float, and to cushion shock loads. Where required for vertical shafts, 3-piece spacer couplings or

universal type couplings for extended shafts shall be installed. Unless otherwise indicated, or recommended by the equipment Manufacturer, gear or flexible spring type coupling shall be furnished with horizontal and end suction pumps.

- B. The equipment Manufacturer shall recommend the size and type of coupling required to suit each specific application.
- C. Taper-lock bushings may be used to provide for easy installation and removal on shafts of various diameters.
- D. Where universal type couplings are shown, they shall be of the needle bearing type construction, equipped with commercial type grease fittings.

2.06 SHAFTING

- A. General: All shafting shall be continuous between bearings and shall be sized to transmit the power required. Keyways shall be accurately cut in line. Shafting shall not be turned down at the ends to accommodate bearings or sprockets whose bore is less than the diameter of the shaft. Shafts shall rotate in the end bearings and shall be turned and polished, straight, and true.
- B. Design Criteria: Shafts shall be designed to carry the steady state and transient loads suitable for unlimited number of load applications. Where shafts are subjected to fatigue stresses, such as frequent start and stop cycles, the mean stress shall be determined by using the modified Goodman Diagram. The maximum torsional stress shall not exceed the endurance limit of the shaft after application of the factor of safety of 2 in the endurance limit and the stress concentration factor of the fillets in the shaft and keyway. Stress concentration factor shall be in accordance with ASME Standard B17.1 – Keys and Keyseats.
- C. Materials: Shafting materials shall be appropriate for the type of service and torque transmitted. Environmental elements such as corrosive gases, moisture, and fluids shall be taken into consideration. Materials shall be as shown or specified unless furnished as part of an equipment assembly.
 - 1. Low carbon cold-rolled steel shafting shall conform to ASTM A 108, Grade 1018.
 - 2. Medium carbon cold-rolled shafting shall conform to ASTM A 108, Grade 1045.
 - 3. Corrosion-resistant shafting shall be stainless steel or Monel, whichever is most suitable for the intended service.
- D. Differential Settlement: Where differential settlement between the driver and the driven equipment may occur, an extension shaft with two sets of universal type couplings shall be provided.

2.07 BEARINGS

- A. General: Bearings shall conform to the standards of the Anti-Friction Bearing Manufacturers Association, Inc. (AFBMA).

- B. To assure satisfactory bearing application, fitting practice, mounting, lubrication, sealing, static rating, housing strength, and other important factors shall be considered in bearing selection.
- C. Re-lubricatable type bearings shall be equipped with a hydraulic grease fitting in an accessible location and shall have sufficient grease capacity in the bearing chamber.
- D. All lubricated-for-life bearings shall be factory-lubricated with the Manufacturer's recommended grease to insure maximum bearing life and best performance.
- E. Bearing Life: Except where otherwise specified or shown, all bearings shall have a minimum L-10 life expectancy of 80,000 hours.
- F. Bearing housings shall be of cast iron or steel and bearing mounting arrangement shall be as specified or shown, or as recommended in the published standards of the Manufacturer. Split-type housings may be used to facilitate installation, inspection, and disassembly.
- G. Sleeve-type bearings shall have a Babbitt or bronze liner.

2.08 GEARS AND GEAR DRIVES

- A. Unless otherwise specified, gears shall be of the spur, helical or spiral-bevel type, designed and manufactured in accordance with AGMA Standards, with a minimum service factor of 1.7, a minimum L-10 bearing life of 80,000 hours and a minimum efficiency of 94 percent. Worm gears shall not be used, unless specifically acceptable to the ENGINEER.
- B. Gear speed reducers or increasers shall be of the enclosed type, oil- or grease lubricated and fully sealed, with a breather to allow air to escape but keep dust and dirt out. The casing shall be of cast iron or heavy-duty steel construction with lifting lugs and an inspection cover for each gear train. An oil level sight glass and an oil flow indicator shall be provided, arranged for easy reading.
- C. Gears and gear drives as part of an equipment assembly shall be shipped fully assembled for field installation.
- D. Material selections shall be left to the discretion of the Manufacturer. Input and output shafts shall be adequately designed for the service and load requirements. Gears shall be computer-matched for minimum tolerance variation. The output shaft shall have 2 positive seals to prevent oil leakage.
- E. Oil level and drain location relative to the mounting arrangement shall be easily accessible. Oil coolers or heat exchangers with all required appurtenances shall be furnished when necessary.
- F. Where gear drive input or output shafts connect to couplings or sprockets supplied by others, the gear drive Manufacturer shall supply matching key taped to the shaft for shipment.

2.09 DRIVE CHAINS

- A. Power drive chains shall be commercial type roller chains complying with ANSI standards and of materials best suited for the process fluid.
- B. A chain take-up or tightener shall be provided in every chain drive arrangement to provide easy adjustment.
- C. A minimum of one connecting or coupler link shall be provided with each length of roller chain.

2.10 SPROCKETS

- A. Sprockets shall be used in conjunction with chain drives and chain-type material handling equipment.
- B. Materials: Sprockets shall comply with the following unless otherwise specified elsewhere:
 - 1. Sprockets with 25 teeth or less, normally used as a driver, shall be medium carbon steel in the 0.40 to 0.45 percent carbon range.
 - 2. Type A and B sprockets with 26 teeth or more, normally used as driven sprockets, shall be made of minimum 0.20 percent carbon steel.
 - 3. Large diameter sprockets with Type C hub shall be cast iron conforming to ASTM A48, Class 30.
- C. Sprockets shall be accurately machined to ANSI Standards. Sprockets shall have deep hardness penetration in tooth sections.
- D. Finish bored sprockets shall be provided complete with keyseat and set screws.
- E. To facilitate installation and disassembly, sprockets shall be of the split type or shall be provided with taper-lock bushings as required.
- F. Idler sprockets shall be provided with brass or Babbitt bushings, complete with oil hole and axial or circumferential grooving. Steel collars with set screws in both sides of the hub shall be provided.

2.11 V-BELT DRIVES

- A. V-belts and sheaves shall be of the best commercial grade and shall conform to ANSI, MPTA, and RMA Standards.
- B. Unless otherwise specified, sheaves shall be machined from the finest quality gray cast iron.
- C. Sheaves shall be statically and dynamically balanced. In some applications where vibration is a problem, sheaves shall be dynamically balanced. Sheaves operating at belt speeds exceeding 6,500 fpm may require to be of special materials and construction recommended by the Manufacturer.

- D. To facilitate installation and disassembly, sheaves shall be furnished complete with taper lock or QD bushings as required.
- E. Finish bored sheaves shall be furnished complete with keyseat and set screws.
- F. Sliding motor bases with jack bolts shall be provided to adjust the tension of V-belts.

2.12 DRIVE GUARDS

- A. Power transmission, prime movers, machines, shaft extensions, and moving machine parts shall be guarded in accordance with the OSHA Safety and Health Standards (29CFR1910.211 to 1910.219). The guards shall be constructed of minimum 10 gauge expanded; flattened steel with smooth edges and corners, stainless steel after fabrication and securely fastened. Where required for lubrication or maintenance, guards shall have hinged and latched access doors.

2.13 FLEXIBLE CONNECTORS

- A. Flexible connectors shall be installed in all piping connections to engines, blowers, compressors, and other vibrating equipment with the requirements of the ANSI B31.1.

2.14 INSULATING CONNECTIONS

- A. Insulating bushings, unions, couplings, and flanges, shall comply with the requirements of Section 15120 – Piping Specialties.

2.15 GASKETS AND PACKINGS

- A. Gaskets for flanged connections shall comply with the requirements of Section 15120 – Piping Specialties.
- B. Packing around valve stems and reciprocating shafts shall be of compressible material, compatible with the fluid being used. Chevron-type "V" packing shall be Garlock No. 432, or John Crane "Everseal".
- C. Packing around rotating shafts (other than valve stems) shall be "O"-rings, stuffing boxes, or mechanical seals, as recommended by the Manufacturer and acceptable to the ENGINEER.

2.16 NAMEPLATES

- A. Equipment nameplates of 316 stainless steel shall be engraved or stamped and fastened to the equipment in an accessible location with No. 4 or larger oval head 316 stainless steel drive pins. Adhesives shall not be used in lieu of 316 stainless steel screws. Nameplates shall contain the Manufacturer's name, model, serial number, size, characteristics, date of Manufacture, and appropriate data describing the machine performance ratings.

2.17 SAFETY REQUIREMENTS

- A. Where Work areas are located within a flammable or toxic gas environment, suitable gas detection, ventilating, and oxygen deficiency equipment shall be provided. Workers shall be equipped with approved breathing apparatus.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General: Equipment shall be installed in accordance with the Manufacturer's written recommendations and the requirements of the individual equipment specification sections.
- B. Alignment: Journeymen millwrights shall perform alignment of equipment furnished herein. The OWNER's Field Representative will witness final alignment procedures of equipment.
- C. Field Assembly: Studs, cap screws, bolt and nuts used in field assembly shall be coated with Never Seize compound or equal.
- D. Welding: Welds shall be cleaned of weld-slag, splatter, etc. to provide a smooth surface.
- E. Insulating Connections: All insulating connections shall be installed in accordance with the Manufacturer's printed instructions.
- F. Pipe Hangers, Supports, and Guides: Hangers, supports, and guides shall be spaced in accordance with Section 15140 – Supports and Hangers, as shown on the Drawings and ANSI/ASME B.31.1 standard.

3.02 PACKAGED EQUIPMENT

- A. When any system is furnished as pre-packaged equipment, the CONTRACTOR shall coordinate space and structural requirements, clearances, utility connections, signals, and outputs with Subcontractors to avoid later change orders.
- B. If the packaged system has any additional features (as safety interlocks, etc.) other than required by the Contract Documents, the CONTRACTOR shall coordinate such features with the ENGINEER and provide material and labor necessary for a complete installation as required by the Manufacturer.

3.03 FIELD TESTS

- A. Where indicated by the individual equipment sections, equipment shall be field tested after installation to demonstrate satisfactory operation without excessive noise, vibration, or overheating of bearings or motor.
- B. The following field testing shall be conducted:

1. Start equipment, check, and operate the equipment over its entire operating range. Vibration level shall be within the amplitude limits as indicated or as recommended by the reference applicable standards.
 2. Obtain concurrent readings of motor voltage, amperage, capacity, vibration, and bearing temperatures.
 3. Operate equipment indicated in Section 01650 – Facility Start-Up / Commissioning.
- C. The ENGINEER will witness field-testing. The CONTRACTOR shall notify the ENGINEER of the test schedule 3 Days in advance.
- D. In the event that any equipment fails to meet the test requirements, the equipment shall be modified and retested until it satisfies the requirement.
- 3.04 MEASUREMENT AND PAYMENT
- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 11100
PUMPS, GENERAL

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Work of this Section includes providing general requirements for pumps and pumping appurtenances and providing special tools and spare parts.
- B. The Work also includes coordination of design, assembly, testing and installation.
- C. The CONTRACTOR shall provide all pumps and pumping appurtenances, complete and operable, in accordance with the Contract Documents.
- D. The provisions stated herein and in the individual pump Sections shall apply to all pumps and pumping equipment except where otherwise indicated in the Contract Documents. In case of conflict between this Section and individual pump Section, the requirements of individual pump Section will govern.
- E. Unit Responsibility: A single Manufacturer shall be responsible for furnishing the Work and for coordination of design, assembly, testing, and installation of the Work of each pump Section; however, the CONTRACTOR shall be responsible to the OWNER for compliance with the requirements of each pump Section. Unless otherwise indicated, the single Manufacturer will be the Manufacturer of the pump.
- F. Single Manufacturer: Where two or more pump systems of the same type or size are required, the pumps shall all be produced by the same Manufacturer.

1.02 SUBMITTALS

- A. Submit required information in accordance with Section 01300 – Submittals.
- B. All submittals shall use English units and shall be written in English.
- C. Shop Drawings: The shop drawings shall contain the following information:
 - 1. Pump name, identification number, and Specification Section number.
 - 2. Performance data curves showing head, capacity, horsepower demand, NPSH required, and pump efficiency over the entire operating range of the pump. The equipment Manufacturer shall indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the rated, design, maximum and minimum flow conditions. Pump inlet, bowl, column and discharge head losses for vertical column pumps shall be shown separately. Curves for variable speed pumps shall be provided in 10 percent increment from 50% to 100% of full speed.
 - 3. The pump Manufacturer to indicate the recommended preferred operating region and allowable operating region on the performance curves for stable operation without surge, cavitation, or excessive vibration. Under no circumstances shall the Manufacturer's recommended operating range be less than that required to meet

the pump operating conditions specified. The stable operating range shall be as wide as possible based on actual hydraulic and mechanical tests.

4. NPSH margin calculation performed in accordance with HI Standards.
5. Drawings showing general dimensions and conforming the size of pumps, motors, drives and specified appurtenances, piping connections and construction details of equipment.
6. Assembly and installation drawings including shaft size, seal, coupling, bearings, anchor bolt plan, part nomenclature, material list, outline dimensions, and shipping weights.
7. Data, in accordance with Division 16 – Electrical, for the electric motors proposed for each pump.
8. Variable speed information as required under Division 16 – Electrical.
9. Elevations of proposed Local Control Panel showing panel-mounted devices, details of enclosure type, single line diagram of power distribution, and current draw of panel, and list of all terminals required to receive inputs or to transmit outputs from the Local Control Panel.
10. Wiring diagrams of field connections with identification of terminations between Local Control Panels, junction terminal boxes, and equipment items.
11. Complete electrical schematic diagrams.
12. Complete description and sketch of proposed test setup for factory test if a factory test is required by the requirements of this Section or individual pump Section at least 60 days prior to proposed test date. Submittal material shall include sample calculations and proposed test log format.
13. Factory Test Data: Signed, dated, and certified factory test data for each pump system which requires factory testing, submitted four weeks prior to shipment of equipment.
14. Manufacturer shall provide any and all changes to the Drawings or Specifications required for the equipment being supplied at no additional cost to the OWNER.

D. Certifications

1. A Certificate of Unit Responsibility Assignment signed by officers of both the CONTRACTOR and the Pump Manufacturer Corporations, attesting to the assignment of responsibility in accordance with these Contract Documents. No other submittal material will be reviewed until the certificate has been submitted and found to be in conformance with these requirements.
2. A certified statement from the pump Manufacturer that the pump Manufacturer has reviewed the suction and discharge piping arrangement shown in the Drawings and is acceptable to the Manufacturer for acceptable cavitation and proper operation of the pumps to be furnished and warranted as installed. Any modification required to the suction and discharge piping as required by the pump Manufacturer shall be performed by the CONTRACTOR at no additional cost to the OWNER.
3. If factory tests are required by these Specifications, submit certification of satisfactory testing of each unit as specified. The certified material shall include copies of test logs and resulting performance curves at least four weeks prior to shipping the units from the factory. Manufacturer's reports on hydrostatic tests, including calibration test results on all instruments used to conduct the factory tests.

4. Manufacturers' certification of proper installation.
 5. Satisfactory field testing certification of the pumping units
- E. Owner's Manual: Submit Operation and Maintenance manual in accordance with Section 01730 – Operations and Maintenance Data. Operations and Maintenance manuals shall include data for each pumping unit, including pump, and motor. The Owner's Manual shall contain following:
1. Manufacturer's written guarantee that pumping equipment operates with efficiencies, heads and flow ranges indicated and meets vibration and noise requirements.
 2. If factory tests are required by these Specifications, certified copies of test logs and resulting performance curves shall be included in the manual. Manufacturer's reports on hydrostatic tests including calibration test results on all instruments used to conduct the factory hydrostatic and performance tests shall also be included in the manual.
 3. Vibration and noise measurement results.

1.03 REFERENCE STANDARDS

- A. Design, manufacture, and assembly of elements of the equipment herein specified shall be in accordance with, but not limited to, published standards of the following, as applicable:
1. ANSI/AWWA E102 – Submersible and Vertical Turbine Pumps
 2. ANSI/AWWA E103 – Horizontal and Vertical Line-Shaft Pumps
 3. ANSI/HI 2.1 – 2.4 & 2.6 – Vertical Pumps
 4. ANSI/HI 9.1 – 9.5 – Pumps – General Guidelines for Types, Definitions, Application, Sound Measurement and Decontamination
 5. ANSI/HI 9.6.1 – Rotodynamic Pumps Guideline for NPSH Margin
 6. ANSI/HI 9.6.2 – Rotodynamic Pumps for Assessment of Applied Allowable Nozzle Loads
 7. ANSI/HI 9.6.3 – Rotodynamic (Centrifugal and Vertical) Pumps – Guideline for Allowable Operating Region
 8. ANSI/HI 9.6.4 – Rotodynamic Pumps for Vibration Measurements and Allowable Values
 9. ANSI/HI 9.6.6 – Rotodynamic Pumps for Pump Piping
 10. ANSI/HI 9.8 – Rotodynamic Pumps for Intake
 11. American Iron and Steel Institute (AISI)
 12. American Society of Mechanical Engineers (ASME)
 13. American National Standards Institute (ANSI)
 14. American Society for Testing Materials (ASTM)
 15. American Welding Society (AWS)
 16. Anti-Friction Bearing Manufacturer's Association (AFBMA)
 17. Institute of Electrical and Electronics Engineers, Inc. Standard Test Procedures for Polyphase Induction Motors and Generators IEEE 112 or latest standard
 18. National Electrical Code (NEC)

19. National Electrical Manufacturers Association (NEMA) NEMA MG 1 – Motors and Generators or latest standard
20. Occupational Safety and Health Administration (OSHA)
21. Steel Structures Painting Council (SSPC)

1.04 QUALITY ASSURANCES

- A. At least three successfully operating installation of comparable size and complexity (including no cavitation, damaging vibration or shaft damage within the first three years of operation) designed and installed in the recent past by the Pump Manufacturer, with contact name, telephone number and address, shall be submitted to the ENGINEER for review.
- B. Services of Manufacturer's Representative
 1. Manufacturer's services shall be in accordance with requirements noted herein and in the individual pump Sections.
 2. Inspection, Start-Up, and Field Adjustment: Where required by the individual pump Sections, an authorized service representative of the Manufacturer shall visit the site for the number of days indicated in those Sections to witness the following and to certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and ready for operation.
 - a. Unloading and storage of the equipment
 - b. Installation of the equipment
 - c. Inspection, checking, and adjusting the equipment
 - d. Start-Up and field testing for proper operation
 - e. Performing field adjustments to ensure that the equipment installation and operation comply with requirements.
 3. Instruction to the OWNER's Personnel
 - a. Where required by the individual pump Sections, an authorized training representative of the Manufacturer shall visit the site for the number of days indicated in those Sections to instruct the OWNER's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with necessary test equipment. Instruction shall be specific to the models of equipment provided.
 - b. The representative shall have at least five years of experience in training OWNER's personnel. A resume for the representative shall be submitted.
 - c. Training shall be scheduled a minimum of three weeks in advance of the first session of the training schedule.
 - d. Proposed training material and a detailed outline of each lesson shall be submitted for review. Comments shall be incorporated into the material.
 - e. The training materials shall remain with the trainees.
 - f. The OWNER will videotape in DVD format the training for later use in training OWNER's personnel.

1.05 DELIVERY, HANDLING AND STORAGE

- A. The Pump Manufacturer shall provide unloading, storage, and handling instructions prior to shipment.
- B. Pumping units shall be shipped with the motor space heaters connected to a terminal board and ready to be energized.
- C. All equipment shall be delivered to the CONTRACTOR in good, sound condition, and free from damage. Equipment which has been damaged will be rejected. Pump Manufacturer's representative shall be on the site to witness the arrival, inspection, and unloading process as specified in individual specification Section.
- D. The CONTRACTOR shall be responsible for proper unloading, handling, and storage of equipment in accordance with the Manufacturer's instructions. Motor space heaters shall be promptly energized and pumping units shall be housed in weatherproof enclosures at all times during storage. The motor oil reservoirs shall be filled with oil promptly after arrival. The CONTRACTOR shall rotate the motor shaft by hand three to four revolutions on a weekly basis until the units are started.

1.06 MAINTENANCE/SPARE PARTS

- A. Maintenance/spare parts shall be provided in accordance with each individual equipment Section.

PART 2 PRODUCTS

2.01 GENERAL

- A. Compliance with the requirements of the individual pump Sections may necessitate modifications to the Manufacturer's standard equipment.
- B. Performance Curves: All centrifugal pumps shall have a continuously rising curve towards the shutoff head. In no case will the required horsepower at any point on the performance curve exceed the rated horsepower of the motor without using service factor of the motor or engine.
- C. All components of each pump system provided under the pump Sections shall be entirely compatible. Each unit of pumping equipment shall incorporate all basic mechanisms, couplings, electric motors or engine drives, variable speed controls, necessary mountings, and appurtenances.

2.02 MATERIALS

- A. All materials shall be suitable for the intended application; materials not specified shall be high-grade, standard commercial quality, free from all defects and imperfection that might affect the serviceability of the product for the purpose for which it is intended, and shall conform to the following requirements:
 - 1. Cast iron pump casings and bowls shall be of close-grained gray cast iron, conforming to ASTM A 48 or ASTM A278, and shall not be less than Class 30, or

ductile iron conforming to ASTM A 536 GR 65-14-12 or ASTM A395 as appropriate. Casing shall be of sufficient thickness and suitably ribbed, if necessary, to withstand all stresses and strains to which it may be subjected during installation, testing, and operation. Casing shall be free of bowholes, sand holes, and other detrimental defects, with smooth water passages.

2. Stainless steel pump impellers shall conform to ASTM A 743 – Grade CF-3M, 316L. Bronze pump impellers where indicated shall conform to the requirements of ASTM B62 or ASTM B584.
3. Stainless steel pump shafts shall be Type 416 or 316. Miscellaneous stainless steel parts shall be of Type 316, except Type 304 in septic environment.
4. Anchor bolts, washers, and nuts shall be in accordance with Section 15120 – Piping Specialties.

2.03 PUMP COMPONENTS – GENERAL

- A. Flanges: Suction and discharge flanges shall conform to ANSI/ASME B16.1 – Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800 or B16.5 – Pipe Flanges and Flanged Fittings dimensions. Bolts and nuts shall be in accordance with Section 15120 – Piping Specialties.
- B. Lubrication: Vertical pump line shaft bearings of a clean water pump shall be a product water-lubricated, unless otherwise indicated. Deep-well pumps and pumps with enclosed line shafts shall have water- or oil-lubricated bearings and seals. The pumps shaft bearings for sewage, sludge, and other process fluids shall be lubricated as indicated.
- C. Hand holes: Hand holes on pump casings shall be shaped to follow the contours of the casing to avoid any obstructions in the water passage.
- D. Vortex Suppressors: Vertical pumps with marginal submergence shall be provided with vortex suppressors.
- E. Drains: All gland seals, air valves, cooling water drains, and drains from variable speed drive equipment shall be piped to the nearest floor sink, or drain, with copper pipe or PVC pipe, properly supported with brackets.
- F. Grease Lubrication: For all vertical propellers, mixed-flow, and turbine pumps, other than deep well pumps, of bowl sizes 10 inches and larger, the CONTRACTOR shall provide a stainless steel tube attached to the column for grease lubrication of the bottom bearing.
- G. Stuffing Boxes: Where stuffing boxes are specified for the pump seal, they shall be of the best quality, using the Manufacturer's suggested materials best suited for the specific application. For sewage, sludge, drainage, and liquids containing sediments, the seals shall be freshwater flushed, using lantern rings.
 1. Unless otherwise indicated, the packing material shall be interlaced Teflon braiding, containing 50 percent ultrafine graphite impregnations to satisfy the following:
 - a. Shaft speeds – up to 2500 fpm.
 - b. Temperature – up to 500 degrees F.

- c. pH range – 1-14.
- 2. If fresh water is not available, the seal shall be flushed with product water cleaned by a solid separator as manufactured by John Crane Co., Lakos (Claude Laval Corp.), or equal.
- H. Mechanical Seals: Mechanical seals shall be fresh water-flushed unless specified or indicated otherwise; in which case product water cleaned by a solid separator as above shall be used. Mechanical seals shall be as manufactured by the following, or approved equal, except where specified otherwise in the specific equipment Section:
 - 1. Water Pumps split seals:
Hot and Cold – Chesterton 442 Split seal or John Crane Type 3740
 - 2. Water Pumps single seals:
Hot and Cold – Chesterton 155 Standard Single Seal or John crane Type 1
- I. Where indicated, a buffer fluid must be circulated a minimum 20 psi above discharge pressure, or as required by the Manufacturer, in order to maintain reliable seal performance.
- J. Mechanical seals for all services other than chemicals and corrosives shall be equipped with non-clogging, single coil springs and non-sliding, internal, secondary elastomers. Metal parts shall be Type 316 stainless steel, Alloy 20, or Hastelloy B or C and selected based on the pumped fluid.
- 2.04 SOLE PLATES FOR VERTICAL CENTRIFUGAL PUMPS
 - A. Sole plate for vertical column type pumps shall be designed to be installed on the concrete foundation and shall be milled flat to within .002-inch per foot in all directions on the face matting with the pump support.
- 2.05 BASE PLATES AND DRIVE UNIT SUPPORTS
 - A. Base plate for horizontal pumps shall be sized sufficiently for mounting of pump and motor.
 - B. Base plate shall be free of warping and cupping. Stress relieve the base plate after welding and before machining.
 - C. Base plate shall be designed for grouting on the concrete pump pad.
- 2.06 PUMP APPURTENANCES
 - A. Nameplates: Each pump shall be equipped with a stainless steel nameplate indicating serial numbers, rated head and flow, impeller size, pump speed, and Manufacturer's name and model number. Nameplates shall be attached per Manufacturer's requirements.
 - B. Gages
 - 1. All pumps (except sample pumps, sump pumps, and hot water circulating pumps) shall be equipped with pressure gages installed at pump discharge lines. Pump

suction lines shall be provided with compound gages. Gages shall be located in a representative location, where not subject to shock or vibrations, in order to achieve true and accurate readings.

2. Where subject to shock or vibrations, the gages shall be wall-mounted or attached to galvanized channel floor stands and connected by means of flexible connectors.

C. Solenoid Valves: The pump Manufacturer shall provide solenoid valves on the water or oil lubrication lines and all cooling water lines.

D. Thrust restraint: Pump Manufacturer shall design thrust harness for pump suction and discharge piping in accordance with Hydraulic Institute Standards. Pump Manufacturer shall provide this information to the CONTRACTOR. The CONTRACTOR shall provide all restraints exceeding shown on the Drawings that are required by the pump Manufacturer at no additional cost to the OWNER. Restraint hardware shall be 304 Stainless Steel for submerged, buried, or in vaults and will be specified in the standard details. All other locations will be carbon steel.

2.07 FACTORY TESTING

A. The following tests shall be conducted on each indicated pump system:

1. Motors: All motors of sizes 100 hp and larger shall be assembled, tested, and certified at the motor factory and the working clearances checked to insure that all parts are properly fitted. The tests shall be in accordance with Division 16 requirements.
2. Pump Systems: All centrifugal pump systems 10 hp and larger shall be tested at the pump factory in accordance with the American National Standard for Centrifugal Pump Tests (ANSI/HI 1.6 acceptance Level "A") or the American National Standard for Vertical Pump Tests (ANSI/HI 2.6) as approved by ANSI and published by the Hydraulic Institute. Tests shall be performed using the complete pump system to be furnished, including the project motor. For motors smaller than 50 hp, the Manufacturer's certified test motor shall be acceptable. Testing of prototype models will not be acceptable. The following minimum test data shall be submitted:
 - a. Hydrostatic test data.
 - b. A minimum of five hydraulic test readings between shutoff head and 25 percent beyond the maximum indicated capacity recorded on data sheets as defined by the Hydraulic Institute.
 - c. Pump curves showing head, flow, bhp, efficiency, and NPSH requirements.
 - d. Certification that the pump horsepower demand did not exceed the rated motor hp beyond the 1.0 service factor rating at any point on the curve.
3. Factory Witnessed Tests: All pumps, variable speed drives, and motors, 150 hp and larger shall be factory-tested as complete assembled systems and may be witnessed by the OWNER and ENGINEER. The CONTRACTOR shall give the ENGINEER a minimum of 3 weeks notification prior to the test. All costs for the OWNER and ENGINEER shall be borne by the CONTRACTOR and shall be included in the bid price. Unless specified in individual pump Section such costs shall include travel (to the closest commercial airport) and subsistence for two people excluding salaries. Test results shall be submitted to the ENGINEER and no equipment shall be shipped until the test data have been accepted by the ENGINEER.

4. Acceptance: In the event of failure of any pump to meet any of the requirements, the CONTRACTOR shall make all necessary modifications, repairs, or replacements to conform to the requirements of the Contract Documents and the pump shall be re-tested at no additional cost to the OWNER until found satisfactory.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General: Pumping equipment shall be installed in accordance with the Manufacturer's written recommendations.
- B. Alignment: All equipment shall be field tested to verify proper alignment, operation as specified, and free from binding, scraping, vibration, shaft runout, or other defects. Pump drive shafts shall be measured just prior to assembly to ensure correct alignment without forcing. Equipment shall be secured in position and neat in appearance.
- C. Manufacturer's field representative shall inspect the installation of the pumping units and provide a certificate of proper installation to the OWNER.
- D. Lubricants: The CONTRACTOR shall provide the necessary oil and grease for initial operation.

3.02 PAINTING / PROTECTIVE COATINGS

- A. Materials and equipment shall be coated as required in individual Sections and Section 09900 – Painting.

3.03 FIELD TESTS

- A. Where required by the individual pump Sections, each pump system shall be field tested after installation to demonstrate satisfactory operation without excessive noise, vibration, cavitation, or overheating of bearings.
- B. The following field testing shall be conducted:
 1. Start-Up, check, and operate the pump system over its entire speed range. Unless otherwise specified, vibration shall be within the amplitude limits recommended by the Hydraulic Institute Standards at a minimum of four pumping conditions defined by the ENGINEER.
 2. Obtain concurrent readings of motor voltage, amperage, pump suction head, and pump discharge head for at least four pumping conditions at each pump rotational speed. Check each power lead to the motor for proper current balance.
 3. Determine bearing temperatures by contact type thermometer. A run time of at least 20 minutes, or until temperature is stabilized, shall precede this test, unless insufficient liquid volume is available.
 4. Electrical and instrumentation tests shall conform to the requirements of the Sections under which that equipment is specified.
- C. Field testing will be witnessed by the ENGINEER. The CONTRACTOR shall furnish three days advance notice of field-testing.

- D. In the event any pumping system fails to meet the test requirements, it shall be modified and retested as above until it satisfies the requirements.
- E. After each pumping system has satisfied the requirements, the CONTRACTOR shall certify in writing that it has been satisfactorily tested and that all final adjustments have been made. Certification shall include the date of the field tests, a listing of all persons present during the tests, and the test data.
- F. The CONTRACTOR shall bear all costs of field tests, including related services of the Manufacturer's representative, except for power and water, which the OWNER will bear. If available, the OWNER's operating personnel will provide assistance in field testing.

3.04 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 11216

VERTICAL TURBINE PUMPS – WET PIT

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish two (2) vertical turbine, wet pit pumping units, complete with motors, baseplates, couplings and guards, as shown on the Drawings and as specified herein.

1.02 RELATED WORK

- A. Drawings and all provisions of the contract documents shall apply to this Section.
- B. Division 1 – General Provisions
- C. Section 03600 – Grout
- D. Section 09900 – Painting
- E. Division 11 – Equipment
- F. Division 16 – Electrical
- A. Division 17 – Instrumentation

1.03 SUBMITTALS

- A. Submit shop drawings and product data in accordance with Section 01300 – Submittals showing materials of construction, details of fabrication, and installation of items furnished herein. This information shall include, but is not limited to:
 - 1. Certified dimensional drawings of each item of equipment and auxiliary apparatus to be furnished, including equipment weights and location and size of anchor bolts.
 - 2. Certified pump support and anchor bolt plans and details.
 - 3. Certified analysis of impeller composition.
 - 4. Literature and drawings describing the equipment, including parts list and materials of construction, in sufficient detail to indicate full conformance with the detail specifications.
 - 5. Motor performance data, wiring diagrams, one-lines and conduit entry dimensions and details. Other submittals as required by Division 16.
 - 6. Cut sheets on accessory items.
 - 7. Manufacturer's installation instructions.
 - 8. Pump/motor coupling manufacturer, model number, AGMA 9002-A clearances and tolerances.
 - 9. Manufacturer's certified rating curves, to satisfy the specified design conditions, showing pump characteristics of discharge, head, brake horsepower, efficiency and net positive suction head required (NPSH_R). Curves shall show the full recommended range of performance and include shut off head. This information shall be prepared

specifically for the pump proposed. Catalog sheets showing a family of curves will not be acceptable.

10. Adherence to Quality Control requirements listed herein.
11. Test Reports as specified herein.
12. Qualifications of service engineer to perform installation inspection and Manufacturer's Field Report.
13. Manufacturer's Field Report, including the following:
 - a. Report of installation, inspection, testing and observations for each pumping unit.
 - b. Letter of Certification of Compliance.
14. Certification: A statement from the Pump Manufacturer that the Manufacturer has reviewed the discharge piping arrangement shown in the Drawings and is acceptable to the Manufacturer for the satisfactory operation of the pumps to be furnished. Any modification required to the suction and discharge piping as required by the Pump Manufacturer shall be performed by the CONTRACTOR at no additional cost to the OWNER.

B. Operation and Maintenance Data

1. Complete operating and maintenance instructions shall be furnished for all equipment specified in this Section as provided in Section 01730 – Operations and Maintenance Data. The maintenance instructions shall include, but are not limited to:
 - a. Troubleshooting data
 - b. Full preventative maintenance schedules
 - c. Example nameplate
 - d. Complete spare parts lists with ordering information
 - e. Certified performance data and curves from factory tests
 - f. Factory performance test report

1.04 REFERENCE STANDARDS

- A. Design, manufacturing and assembly of elements of the equipment herein specified shall be in accordance with, but not limited to, published standards of the following, as applicable:
 1. American National Standards Institute (ANSI)
 2. American Society for Testing and Materials (ASTM)
 3. American Bearing Manufacturers Association (ABMA)
 4. Hydraulic Institute (HI)
 5. National Electrical Manufacturers Association (NEMA)
- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

- A. To assure unity of responsibility, the motors, couplings, guards and supporting base shall be furnished by the pump manufacturer. All pumping units specified herein shall be furnished by a single manufacturer.
- B. The equipment specified herein is intended to be of proven ability as manufactured by companies having extensive experience in the production of such equipment. The equipment furnished shall be designed, constructed and installed to operate satisfactorily when installed as shown on the Drawings. Pumps shall be manufactured in accordance with HI standards, except where otherwise specified herein.
- C. The pump manufacturer shall be fully responsible for the design, arrangement and operation of all connected rotating components as assembled to ensure that neither harmful nor damaging vibrations occur at any speed within the specified operating range.
- D. Vibration, when measured in the direction of maximum amplitude on the pump and motor bearing housings, shall not exceed limits given in the latest ANSI/HI nomograph for the applicable pump type.
- E. Manufacturer shall have installations of like or similar application with a minimum of five (5) years' service for this pump size.
- F. Pumps are to be engineered and manufactured under a written Quality Assurance program. The Quality Assurance program is to be in effect for at least ten (10) years, to include a written record of periodic internal and external audits to confirm compliance with such program.
- G. Pumps are to be engineered and manufactured under the certification of ISO-9001.
- H. Acceptable Manufacturer:
 - 1. Flowserve Choice

1.06 SERVICES OF MANUFACTURER'S REPRESENTATIVE

- A. A pump Manufacturer's factory certified service engineer who has complete knowledge of proper installation, Start-Up, testing, operation, and maintenance of the pumping system components as herein specified shall be provided as noted herein and in Section 01730 – Operation and Maintenance Data to test, calibrate, and place into service this equipment. Submit qualifications of service engineer for approval.
 - 1. The factory certified service engineer shall advise, consult, and instruct the CONTRACTOR on installation procedures and adjustments and inspect the operators during installation as a condition of acceptance of the Work.
 - 2. The factory certified service engineer shall be present during all Start-Up and testing operations to make final adjustments as a condition of acceptance of the Work.
- B. A pump Manufacturer approved representative shall be provided to instruct the OWNER's plant operation and maintenance personnel in the proper operation and

maintenance (O&M) of the equipment in accordance with the provisions of Section 01730 – Operation and Maintenance Data and as specified herein.

1. Operating and maintenance manuals shall be furnished to the OWNER as provided in Section 01730 – Operations and Maintenance Data. The manuals shall be prepared specifically for this installation and shall include all required cut sheets, drawings, equipment lists, descriptions, etc. that are required to instruct operating and maintenance personnel unfamiliar with the progressive cavity pump operation and maintenance. In addition to the requirements of Section 01730 – Operation and Maintenance Data, the manuals shall include the following at a minimum:
 - a. Complete parts list, cross-referenced to exploded view assembly drawings.
 - b. Dimensional drawings for all provided components with their respective weights.
2. OWNER training shall be provided and shall include operational instructions to three separate operational teams over a minimum of three separate time periods, Training shall be given at times convenient to the operational team being trained in light of 12-hour operational shifts and duties while on shift. Accordingly, some operational training will have to be conducted during hours outside a normal Monday through Friday, 7:00 am to 3:00 pm EST.
3. Operational training shall include the following at a minimum:
 - a. Control and operation of all equipment and appurtenances provided with the pumps.
 - b. Trouble shooting guidance.
 - c. Recognizing normal and abnormal operating conditions.
4. OWNER training shall also include maintenance instructions to one maintenance team. Maintenance training shall be conducted during the hours of 7:00 AM to 3:00 PM EST, Monday through Friday, with exact schedule being determined in light of on-going maintenance team duties. Maintenance training shall include the following, at a minimum:
 - a. Lubrication procedures.
 - b. Torque and limits switch adjustment.
 - c. Recommended routine maintenance procedures.
 - d. Trouble-shooting and diagnostic procedures.
 - e. Fuse and pilot lamp replacement.

- C. Person-hour requirements tabulated below are exclusive of travel time and do not relieve the CONTRACTOR of obligation to provide sufficient services to place all equipment and appurtenances into satisfactory operation.

Services to be Provided by the Factory Representative	Minimum Number of Trips(a)	Minimum Time On-site Per Trip (Hours)
1. Supervise setting of pump bases prior to grouting	1	8
2. Supervise installation of pumps and check pump leveling and pre-alignment(b)	1	8
3. Inspect final pump alignment	1	8
4. Demonstrate start-up and initial run to demonstrate successful operation	1	8
5. Supervise OWNER in proper start-up and O&M(c)	1	8

(a) Service engineer shall be present at frequent enough intervals to ensure proper installation, testing, and initial operation of the equipment.

(b) This assumes all pumps are shipped together. Additional trips shall be included for additional shipments.

(c) Service engineer shall be present as necessary to operate successfully following Start-Up, at no additional cost to OWNER.

1. In the event the services of the service engineer are needed and requested by the CONTRACTOR for periods longer than indicated in these Contract Documents, payment for such services shall be made by the CONTRACTOR. No payment shall be due for time spent by the representative due to faulty design or fabrication of the equipment.

1.07 DELIVERY, STORAGE AND HANDLING

- A. All parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and the unit and equipment are ready for operation.
- B. All equipment and parts must be properly protected against any damage during shipment. The CONTRACTOR shall store equipment in accordance with the manufacturer's instruction.

1.08 MAINTENANCE

- A. Furnish all special tools and test equipment required for the proper servicing of all equipment.
- B. Pump Spare Parts: Furnish the following spare parts for each size of pump in a given service.
 1. One set of pump bearings

2. One set of shaft sleeves
 3. One set of wear rings (if applicable)
 4. One set of packing
 5. One set O-rings
- C. Motor/Coupling Spare Parts: Furnish the motor Manufacturer's standard set of spare parts for each size pump, including at least the following:
1. One (1) complete set of motor thrust bearings
- D. One (1) gallon of touch up paint for each paint or protective coating of the pumping unit components.
- E. Maintenance Tools: Furnish one set of all special tools required for proper Start-Up and maintenance services of equipment supplied herein, packed in a suitable steel tool chest with a lock.
- F. Special tools: Manufacturer shall provide a lock collet tool.

1.09 PERFORMANCE GUARANTEE

- A. The CONTRACTOR shall guarantee the performance of each pumping unit to meet or exceed the specified performance. The guarantee shall include the complete pumping unit assembly, and shall cover speed, capacity, head, efficiency, brake horsepower, motor horsepower, and the performance curves for the pump. The capacity, head, and efficiency guarantee shall apply to the Rated Point on the pump's head capacity curve at the specified head and capacity specified herein. If the pumping units fail to meet the Pump Overall Efficiency at Rated Point, corrective measures shall be taken at no additional cost to the OWNER.

1.10 EQUIPMENT WARRANTY

- A. Equipment warranty shall be one (1) year from OWNER's written acceptance of the pumping units following substantial completion. Manufacturer's warranty shall not relieve the CONTRACTOR from furnishing a complete system warranty as specified in the General Conditions.

PART 2 PRODUCTS

2.01 GENERAL

- A. The complete pumping units shall all be supplied by a single manufacturer and shall be complete including pumps, motors, baseplates, couplings, guards and other accessories as specified herein.
- B. The pumps, motors, drives, couplings and base plates shall be designed and built for 24-hour continuous service at any and all points within the specified range of operation, without overheating, without damaging cavitation, and without excessive vibration or noise.

- C. Each major piece of equipment shall be furnished with a 316 stainless steel nameplate (with embossed data) securely mounted to the body of the equipment. As a minimum, the nameplate for the pumps shall include the equipment tag, manufacturer's name and model number, serial number, rated flow capacity, head and speed. As a minimum, nameplates for motors shall include the equipment tag, manufacturer's name and model number, serial number, horsepower, speed, input voltage, amps, number of cycles, power and service factors.

2.02 CONDITIONS OF OPERATION

- A. Pumps shall be designed to pump non-potable water.
- B. Pumps shall have a 6-inch discharge connection.
- C. Pumping units shall be selected to perform under following operating conditions:

Number of Units	2
Design Capacity (GPM)	520
Total Dynamic Head (FT)	230
Minimum Pump Bowl Efficiency at Design Capacity (%)	82.5
Minimum TDH ¹ (FT)	140
Maximum Shutoff Head (FT)	288
Sump Depth (FT)	9.52
Low Liquid Level (FT)	6.52
Low Low Liquid Level (FT)	5.52
Maximum Pump Speed (RPM)	1800
Maximum Motor Power (HP)	40

¹Total dynamic head shall be as measured at the discharge of the pump and shall include velocity head and vertical static head from the water level to the centerline of the pump discharge.

2.03 PUMP CONSTRUCTION

- A. Design
1. Rotation
 - a. The pump will be counterclockwise rotation when viewed from the driver end looking at the pump.
 2. Discharge Styles
 - a. The discharge elbow shall be located above ground.
 - b. The discharge nozzle is an integral part of the head.
 - c. The discharge nozzle is located 90° to the shaft axis, in any lateral orientation necessary to match the discharge piping.

- d. The driver mounting base is integral with the pump support base unless access to the stuffing box is required above the mounting floor, in which case a driver support stand is supplied.
- 3. Discharge Head Assembly
 - a. Discharge heads shall be of fabricated carbon steel of the proper configuration for the application. Discharge heads shall be free of blow holes, sand holes, and other detrimental defects. Discharge heads shall have 150-pound ANSI flanges.
 - b. Pumps shall be provided with a stuffing box drain connection and a pressure gauge connection.
 - c. The top of the discharge head shall have a registered fit for mounting motor.
 - d. The head shaft shall be 416 stainless steel and shall be turned and ground. The head shaft or top shaft shall not exceed ten (10) feet in length. The pump manufacturer shall include a method of adjusting the pump impellers at the top of the head shaft.
 - e. The pump shall be supplied with a sub-base plate, which shall be grouted in place to which the pump discharge head shall be bolted. This mounting plate will facilitate removal and reinstallation of pumps without re-leveling and grouting.
- 4. Column Assembly
 - a. When column assembly is required, it should be of flanged type construction. The outer column shall be a butt-welded steel pipe, not more than ten (10) feet in length. The ends of each section shall be machined parallel. Register fit circles shall be machined on the flanges on each end and positive alignment shall be assured by accurately machined bearing retainers with register fit circles. The column size shall be such that the friction loss will not exceed 8 feet per 100 feet of length at the rated capacity of the pump. Also, the column size shall be such as to provide a velocity of 10 foot per second, or less, at the rated capacity. The pipe should be A53, Grade B and of sufficient wall thickness for the application.
 - b. A rigid type bearing retainer shall be provided at each column joint for supporting the lineshaft bearings. On 16-inch and larger column sizes, the bearing retainer shall be welded integral to the column pipe. The bearing material shall be dependent upon the temperature and liquid being pumped.
 - c. On 14" and smaller column, utilize drop-in spiders with rubber bearing inserts. Drop-in bearing retainers to be bronze construction.
 - d. When rubber lineshaft bearings are used, 304 stainless steel sleeves shall be provided on the lineshaft at each lineshaft bearing location. These shall be field replaceable and securely fastened to the shaft with a minimum of two set screws.
 - e. When using rubber lineshaft bearings, bearing spacing shall not exceed 10-ft. On pumps with hard lineshaft bearings, bearing spacing shall be sized so that the pump operating speed is at least 20% lower than the pump first critical speed.
- 5. Bowl Assembly
 - a. The pump bowls, including the suction bell, shall be ASTM A48 Class 30 cast iron, free of blow holes, sand holes and other detrimental defects. They shall

be accurately machined with register fit circles, and shall be phenolic coated. All bowls should be of the flanged type construction.

- b. Impellers shall be nickel aluminum bronze. They may be enclosed or semi-open. All impellers shall be statically and dynamically balanced. They shall be securely fastened to the shaft with tapered lock collets, threaded lock collets or double keys. The impellers shall be adjustable vertically by external means at the driver location.
 - c. All pump bowls 20-inch and smaller shall have powder epoxy lined water passageways.
 - d. The pump shaft shall be type 416 stainless steel turned and ground. It shall be supported by bronze bearings above and below each impeller.
 - e. A bowl adaptor or discharge case shall be provided to ensure proper transition from the bowl assembly to the column assembly. It shall contain an extra-long support bearing.
 - f. The suction bell is flared at the bottom to provide a smooth waterway entrance to the impeller and has integral splitters to reduce inlet swirl and entrance losses. The suction bell bearing shall be extra-long and permanently grease packed and sealed with a bronze sand collar.
6. Shafting
- a. Shaft sizes through 3-inch have threaded sleeve couplings of extra heavy wall thickness seamless steel. The size of the shaft shall be no less than determined by ANSI/AWWA Specification E101, Section A4.15 and shall be such that elongation due to hydraulic thrust will not exceed the actual clearance of the impellers in the pump bowls.
 - b. Line shaft shall be of ample size to transmit the torque and operate the pump without distortion or vibration.
7. Basket Strainer
- a. The basket strainer shall be constructed of 316 stainless steel.
8. Sealing System
- a. Mechanical seal
 - (i) For high pressure and critical applications, a cartridge style mechanical seal shall be used. The seal shall be accompanied by a Plan 13 seal flush plan.

B. Analysis

- 1. In order to ensure that neither harmful nor damaging vibrations occur to the pump structure at any speed within the specified operating range, the following analysis shall be required:
 - a. Pump manufacturer shall perform a structural frequency analysis of the above ground structural components utilizing a finite element analysis (FEA) method to ensure that no structural frequencies occur within +/-20% of the operating speed range.
 - b. The FEA method should include the use of ProE/Mechanica or an equivalent software. All pump assembly components, including the motor, shall be represented as solid elements, and if idealizations are used in place of solid elements, then a complete description of method for the idealization shall be

included in the report. The analysis shall also include all modes of interest and pictorially represent them in a fringe plot format. Modes of interest are defined as those structural frequencies that exist below 120% of the maximum operating speed. When significant modifications are required to lower the system's natural frequency, the pump structure's stresses and deflections shall also be reviewed.

- c. Manufacturer to provide documentation of the analysis ensuring that the specified requirements have been met, and that documentation should be signed and stamped by a professionally licensed engineer in the state of Texas.

2. Vibration

- a. When measured in the direction of maximum amplitude on the pump and motor bearing housings, shall not exceed limits given in the latest ANSI/HI nomograph for the applicable pump type.

2.04 PUMP DRIVE SYSTEM

- A. Motors shall have WP1 enclosures of hollowshaft type, with a 1.15 service factor. Motors shall be 460 volt, 3 phase, 60 hertz, and conform to all requirements of Division 16.
- B. Motors shall be US, GE, TECO/Westinghouse or Reliance, no further substitute allowed.
- C. The thrust bearing in the motor is utilized to carry both mechanical and hydraulic thrust of the pump.
- D. Motor are sized for maximum horsepower from shut-off to run-out.
- E. Torque capabilities must exceed those required by the pump at all operating conditions.
- F. This is shown on the pump speed-torque curve, which is available from the factory upon request.
- G. Maximum horsepower and speed as specified under Paragraph 2.02.B.
- H. Each motor shall be given a Complete Motor Performance Test at the motor factory and test results submitted for record.

2.05 BASEPLATES

- A. The pump shall be supplied with a carbon steel sub-base plate (soleplate), which shall be grouted in place to which the pump discharge head shall be bolted. This mounting plate will facilitate removal and reinstallation of pumps without re-leveling and grouting.

2.06 FACTORY TESTS

- A. The ENGINEER shall have the right to witness the factory tests and inspect any equipment to be furnished under this Section prior to their shipment from place of manufacture.
 - 1. A complete test report for each pump, including certified characteristic curves of the pump and certified copies of the hydrostatic test report, shall be submitted to and reviewed by the OWNER and ENGINEER before the pumps are shipped.

- B. Each pump specified herein shall be factory tested in accordance with the latest edition of the Hydraulic Institute Standards. Notification of such test and a list of test equipment and procedures shall be furnished to the ENGINEER at least ten (10) working days before the schedule test date.
 - 1. Each pump shall be tested and data recorded at its operating conditions of service as listed herein. Sufficient test point readings shall be made to establish complete head flow capacity, efficiency and brake horsepower curves for each pump.
 - 2. Tests may be conducted with shop column, discharge head and motor to facilitate the manufacturing process.
 - 3. All gauges and other test instruments shall be calibrated within 30 days of the scheduled test and certified calibration data shall be provided. All Venturi flow meters shall be calibrated as required by ANSI/HI standards.

2.07 SURFACE PREPARATION AND SHOP PRIME PAINTING

- A. All interior and exterior surfaces of pump columns and discharge elbows and the exterior of the bowl assemblies shall be cleaned of all rust and mill scale and supplied with a protective coating in accordance with Section 09900 – Painting.

PART 3 EXECUTION

3.01 INSTALLATION

- A. The CONTRACTOR shall install pumping units as shown on the Drawings and in accordance with the Manufacturer's instructions and approved shop drawings.

3.02 LEVELING

- A. The sole plate shall be set to true level using machinist's level. The tolerance for leveling shall not exceed 2/1000 inch per foot length along any side of the sole plate. The service engineer shall be present during the leveling. The service engineer shall certify that the leveling is in accordance with the limits specified herein and is acceptable to the Manufacturer.

3.03 FIELD TESTS

- A. Functional Tests: Conduct on each pump.
 - 1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
 - 2. Vibration Test:
 - a. Test with units installed and in normal operation, and discharging to the connected piping systems at rates between the low discharge head and high discharge head conditions specified, and with the actual building structures and foundations provided shall not develop at any frequency or in any plane, peak-to-peak vibration amplitudes exceeding the limits specified.
 - b. If units exhibit vibration in excess of the limits specified by the manufacturer, adjust or modify as necessary.
 - 3. Flow Output: Measured by plant instrumentation and storage volumes.

4. Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.
5. Perform noise test of each pumping unit in acceptance with Section 11313 – Pumping Unit Testing.

B. Performance Test: In accordance with ANSI/AWWA E101.

3.04 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 11313
PUMPING UNIT TESTING

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This Section specifies the requirements for complete testing of the pumping units to be furnished and installed under this Contract.

1.02 SUBMITTALS

- A. Submit required information in accordance with Section 01300 – Submittals.
- B. All submittals shall use English units and shall be written in English.
- C. The Pump Manufacturer shall prepare and submit a Factory Test Book for review at least 60 days before any testing is scheduled. The Test Book shall be the test report minus test data and shall contain the following information:
 - 1. Description of tests to be conducted.
 - 2. Description of test procedures.
 - 3. Copy of test standards.
 - 4. Calibration of Instruments: All instruments shall be calibrated in accordance with Hydraulic Institute Standards just prior to factory testing. Manufacturers performing the factory tests shall submit approved certifications of calibration of instruments. Bourdon or bellows gages shall be calibrated at the time of each test.
 - 5. A certified curve showing the calibration of the Venturi meter used in the pump capacity test shall be furnished as part of the data and permanently bound with all other data. The data shall include Venturi coefficient of discharge and flow versus differential head.
 - 6. Dimensional layout of test assembly and reservoir.
 - 7. Photos of test facility.
- D. Field Testing Procedure to be submitted by an Independent Testing Agency to the CONTRACTOR for review by the OWNER, ENGINEER, Pump, Motor and VFD Manufacturers.
- E. Certifications: Submit certification of satisfactory testing of each unit as specified. The certified Factory Test Report shall include copies of test logs and resulting performance curves, noise and vibration test results, and hydrostatic test results. Factory test report shall be certified by a Licensed Professional Engineer and submitted for review by the OWNER/ENGINEER at least four weeks prior to shipping the units from the factory. The report shall also include calibration test results on all instruments used for conducting the factory tests.

1.03 REFERENCE STANDARDS

- A. American National Standard Institute (ANSI)/Hydraulic Institute (HI)
 - 1. ANSI/HI 11.6 – Rotodynamic Submersible Pumps for Hydraulic Performance, Hydrostatic Pressure, Mechanical, and Electrical Acceptance Tests.
 - 2. ANSI/HI 14.6 – Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.

PART 2 PRODUCTS

2.01 FACTORY TESTING

- A. Each pump shall be tested at the Pump Manufacturer's plant with a calibrated motor prior to shipment to confirm that the power consumption of the pumping units to be furnished meets the guaranteed power consumption proposed by the Pumping Unit Manufacturer in the individual pump sections. Each pumping unit shall be tested with water in accordance with ANSI/HI 14.6 – Rotodynamic Pumps for Hydraulic Performance Tests to determine compliance with Pump Manufacturer's head-capacity curve and confirm guaranteed wire-to-water efficiency. Guarantee point acceptance criteria shall be tolerances allowed by Grade 1U for pump head, flow, power and efficiency as defined in Table 14.6.3.4 of HI Standard 14.6. Each pumping unit shall also be tested with VFD close to minimum speed of the pump and record pump performance data. One pumping unit shall be tested with VFD at multiple reduced speeds in 10% increments and record pump performance data. A hydrostatic test shall also be performed on each pressure containing components of the pump. Model tests will not be accepted. Factory testing shall be the final criteria for acceptance by the OWNER for the tests specified herein. Acceptance criteria for vibration as specified herein shall include both factory and field tests. Field testing will be the final criteria for acceptance by the OWNER for the tests specified herein. Factory test data and results shall be submitted for review prior to the equipment being shipped to the jobsite.
- B. Perform NPSH testing on the first unit ready for testing. Determine the Net Positive Suction Head required under both "1% head drop" and at "3% head drop" conditions and provide a composite curve for each. Suction conditions for the test shall duplicate the Net Positive Suction Head available for continuous operation under which the pump will operate.
- C. The factory test report shall be certified by a licensed Professional Engineer. Certified copies of the test data for each pump shall be furnished to the OWNER as part of the Test Book referenced herein. Test curves and data sheets shall include head-capacity curve, brake horsepower curves, overall (wire to water) efficiency curves, Motor Manufacturer's efficiency curves, pump efficiency curves, NPSH requirements, noise and vibration test results and a sketch of the test installation. Data for the entire pump range (from minimum head to shut-off) shall be included. Provide also reduced speed pump curves.
- D. Factory tests shall be made at the speeds and horsepower required by the pump.
- E. All tests for pumps shall be run at specified speeds indicated in the respective specification over the full range of the curve.

- F. Only after receipt, review, and approval of all factory test data, and Preliminary O&M Manuals for pumps, motors and VFDs; the OWNER will give permission to Pump Manufacturer for shipment of pumping units.

2.02 FACTORY TESTS TO BE PERFORMED

- A. Perform all factory testing and comply with the requirements of the individual pump Sections.
- B. Hydrostatic Test: Each new pressure containing parts of the pumps shall be hydrostatically tested to one and one half times its rated pressure or 150 psi, whichever is greater. Rated pressure is defined here as the maximum pressure that would occur in that part when the pump is operated at rated conditions of the pump. Test pressure maintained for not less than 5 minutes.
- C. Performance Test: Record data at a minimum of ten flows vs. head conditions with four of the points being those indicated below. Enough points shall be tested so that a smooth curve may be drawn through the points. Allowable tolerances for the desired points shall be as specified herein and defined in the Hydraulic Institute Standards.
 - 1. Shut-off head
 - 2. Rated point
 - 3. Design point
 - 4. Minimum head point for continuous operation without cavitation
- D. NPSHR Tests: Conduct in accordance with Hydraulic Institute Standards, but at both the 1% head drop and 3% head drop conditions. Take at least five (5) points for NPSHR condition over the pump's Allowable Operating Range (A.O.R.). One point will be at each end of the A.O.R. One point will be at approximately at rated point, design point, and minimum head point for continuous operation. An acceptable NPSHR test occurs if the pump required NPSH @ 3% head drop is below the available NPSH by at least the margin specified in the individual pump Sections.
- E. Vibration Tests: Demonstrate the pumping unit runs smoothly during the tests. Vibration readings shall be taken and recorded at points specified herein. Factory acceptance criteria shall be as specified in the individual pump Sections.
- F. Noise Tests: Noise readings shall be taken and recorded at points specified herein.
- G. Vibration and Noise test for all pumping units shall be performed with and without VFD included.

PART 3 EXECUTION

3.01 FIELD TESTS

- A. Start-Up Operation: The OWNER may operate the equipment, after installation and issuance of installation certificate by the Manufacturer for a period of 30 days before performing field tests.

- B. Notification: Thirty days after the equipment installation is certified by the Pump Manufacturer, the OWNER will set a date acceptable to both parties, for final testing of the equipment as requisite for its acceptance by the OWNER.
- C. Field Testing of Pumps: The CONTRACTOR shall retain an Independent Testing Agency to conduct the Field Tests. Tests shall be conducted in accordance with the Hydraulic Institute Standards – Hydraulic Performance Acceptance Tests and herein. Tests shall be open to the Manufacturer or its representative, and shall be made entirely at the expense of the OWNER. However, the OWNER will not pay any expense incurred by any representative of the CONTRACTOR, including Pump, Motor and VFD Manufacturers, in conjunction with witnessing the field test. A factory hydraulic test engineer may be present to observe field testing.
- D. The following field tests will be performed:
 - 1. Head-capacity
 - 2. Input horsepower
 - 3. Vibration analysis
 - 4. Noise measurement
- E. Field Testing Procedure: At least 30 days prior to the tests, the Independent Testing Agency shall submit its test procedure for review and comment by the OWNER, ENGINEER and the Pump, Motor, and VFD Manufacturers. Four copies of the procedure will be submitted to the CONTRACTOR for distribution to the Pump, Motor, and VFD Manufacturers.

3.02 OWNER'S ACCEPTANCE BASIS

- A. The OWNER will accept the pumps after demonstration of proper functioning of all components and upon successful completion of the factory and field acceptance tests.
- B. If the results of the factory and field testing of the pumping units fail to meet the acceptance criteria, the OWNER may reject the pumping units or require the Pump Manufacturer to modify the units to comply with the specified performance. All expense of retesting the units by Independent Testing Agency shall be borne by the CONTRACTOR.

3.03 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 11314

NOISE REQUIREMENTS AND CONTROL

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This Section specifies maximum permissible noise levels and test procedures for measurement of airborne sound from each of the pumps to be installed in the Thickener Complex.

1.02 RELATED WORK

- A. Section 11216 – Vertical Turbine Pumps – Wet Pit
- B. Section 11318 – Progressive Cavity Pumps
- C. Section 11323 – Rotary Lobe Pumps

1.03 SUBMITTALS

- A. Factory test procedure.
- B. Certification: Certified factory noise test report on the actual pumping units to be furnished as per Section 11313 – Pumping Unit Testing.

1.04 REFERENCE STANDARDS

- A. Hydraulic Institute Standards, ANSI/HI 9.1-9.5 Pumps – General Guidelines.
- B. Hydraulic Institute Standards, ANSI/HI 9.2 – Measurement of airborne sound.
- C. IEEE Standard 85 Test Procedure for Motor Noise Level Measurement.

1.05 NOISE LEVEL ACCEPTANCE CRITERIA

- A. Maximum Noise Level: The maximum noise level of each assembled pumping unit located within or outside a structure shall not exceed 90 dBA at a distance of one meter (3 feet) from the nearest surface of the machine and at a height of 1.5 meters (5 feet) from the floor level at the job site. Measurements shall be made on each complete unit, which includes the pump, motor, and coupling.
- B. Method of measurement: Maximum permissible noise (sound pressure) levels are in decibels as read on the "A" weighing network of a standard sound level meter (dBA). All measurements are to be made in relation to a reference pressure of 0.0002 microbar. Measurements of emitted noise levels shall be made on a sound level meter meeting the requirements of ANSI S1.4, type 1. The octave-band analyzer shall meet the requirements of ANSI S1.11. The sound level meter shall be set on the "A" scale and to slow response.

- C. Measurement Point Location: The location points of measurement of sound level shall be as per HI Standard 9.2.

PART 2 PRODUCTS

2.01 FACTORY TESTS

- A. The Pump Manufacturer shall perform a factory test as per Section 11313 – Pumping Unit Testing on each unit to be furnished, prior to shipment of the units to the job site. Noise level testing analysis shall be made to determine the resulting noise levels for the equipment when operating under specified design conditions, and to determine whether or not the noise exceeds the specified acceptable level. Sound test readings shall be recorded at points specified in Section 11313 – Pumping Unit Testing. Sound level measurements shall be made on the pumping unit under single unit operation. All sound level testing in the factory may be witnessed by the OWNER, ENGINEER, and Motor Manufacturer.

PART 3 EXECUTION

3.01 FIELD TESTS

- A. Testing: Noise testing analysis shall be made to determine the resulting noise levels for the equipment, when operating under field design conditions, and to determine whether or not the noise exceeds the specified level. Sound tests shall be recorded at shut-off head, rated design point, and minimum head point for continuous operation without cavitation. Sound level measurements shall be made on the pumping unit under single unit operation. Prior to the tests, the independent testing laboratory will submit their test procedures for review and comment by both the OWNER and the Pump Manufacturer. All sound level testing, in the field, may be witnessed by the OWNER and ENGINEER, Pump Manufacturer, and Motor Manufacturer.

3.02 FAILURE TO MEET REQUIREMENTS

- A. Excess Noise Level: The equipment will be rejected, in the event that the field noise tests show levels in excess of the allowable limits. The OWNER, at their discretion, may accept the equipment in that case, appropriate field noise reduction measures shall be undertaken to reduce the noise levels at the measurement location(s) to the allowable limits. All field noise reduction measures shall be at the equipment supplier's expense and shall be acceptable to the OWNER and ENGINEER prior to installation.
- B. Corrective methods: Methods to be employed may be in the form of acoustical equipment mountings, acoustical wall or ceiling panels, or acoustical insulation on the equipment. Rated capacities, operation and normal maintenance procedures of the equipment shall not be affected by the noise reduction measures. Providing ear protectors to mitigate excessive noise level is not acceptable.

3.03 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials,

labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 11318

PROGRESSIVE CAVITY PUMPS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The work requires that the Centrifuge Manufacturer accept responsibility for furnishing a complete thickening system as indicated in the Specifications and on the Drawings but without altering the CONTRACTOR's responsibilities under Contract Documents.
- B. The CONTRACTOR shall perform the demolition of the existing progressive cavity discharge pumps as shown on the Drawings. The CONTRACTOR shall furnish labor and materials as required for the storage and installation of the proposed progressive cavity discharge pumps.
- C. The CONTRACTOR shall install and place in satisfactory operation two (2) progressive cavity discharge pumps, equipped complete, as shown on the Drawings and as specified herein. All necessary and desirable accessory equipment and auxiliaries, whether specifically mentioned herein or not, shall be furnished and installed as required for an installation incorporating the highest standards for this type of equipment.
- D. The Centrifuge Manufacturer shall have responsibility to provide a complete and functional thickening system that includes the following components in addition to the progressive cavity discharge pumps. The Centrifuge Manufacturer shall be responsible to provide all equipment and coordinate all controls so the equipment operates as a complete system as intended and described in Section 17920 – Control Narrative:
 - 1. Section 11323 – Rotary Lobe Pumps
 - 2. Section 11330 – Macerators
 - 3. Section 11361 – Centrifuge Thickening Equipment
 - 4. Section 17520 – Instruments
 - 5. Section 17400 – Instrument Panels
 - 6. Other controls and appurtenances needed for a complete and functional system

1.02 RELATED WORK

- A. Drawings and all provisions of the Contract Documents shall apply to this Section, including:
 - 1. Division 1 – General Requirements
 - 2. Division 3 – Concrete
 - 3. Division 5 – Metals
 - 4. Division 9 – Finishes
 - 5. Division 11 – Equipment
 - 6. Division 15 – Mechanical
 - 7. Division 16 – Electrical
 - 8. Division 17 – Instrumentation

1.03 SUBMITTALS

- A. Submit shop drawings and product data in accordance with Section 01300 – Submittals, showing materials of construction, details of fabrication, and installation of items furnished herein. This information shall include, but not be limited to:
1. Complete fabrication, assembly, and installation drawings, showing the Manufacturer's dimensions, weights, and loadings, and descriptive information in sufficient detail to show the kind, size, weight, arrangements, operation, component materials and devices, external connections, anchorages and supports required, performance characteristics, and dimensions needed for installation.
 2. Detailed data covering materials used, parts, instrumentation devices, and other accessories forming a part of the equipment furnished will be submitted for review.
 3. Certified shop and erection drawings showing all important details of construction, dimensions and anchor bolt locations.
 4. Manufacturer's installation instructions.
 5. Detailed cross-section of pump, seals and motor indicating detailed features and materials of construction.
 6. Performance curves for each pump. Curves shall cover range from shutoff to at least 150% of design flow rates, and shall be submitted for the following parameters as a function of capacity at design temperature.
 - a. Discharge pressure
 - b. Required NPSH
 - c. Efficiency
 - d. Required brake horsepower
 7. Electrical data including control wiring. Electrical/pneumatic requirements, schematic diagrams, and details of components including enclosures.
 8. Complete motor and drive data.
 9. Detailed layout drawing of the control wiring termination information in the Centrifuge Control Panel.
 10. Product data on all electrical and control components defining functional requirements and construction.
 11. Painting methods and material data.
 12. Certificate of Compliance or complete list of all deviations from the Drawings and Specifications.
 13. Manufacturer's warranty agreement and special guarantee in compliance with the Contract Documents.
 14. Special shipping, storage and protection, and handling instructions.
 15. Manufacturer's recommended spare parts.
 16. Operation and maintenance manuals in accordance with Section 01730 – Operations and Maintenance Data.
 17. Factory certified service engineer or local Field Service Representative as required herein.
 18. Test procedures, results, reports, and certifications.

19. Manufacturer's Installation Instruction and Certificates for Proper Installation which states that the equipment meets all the design and performance requirements of this Specification.
20. Installation, Start-Up, and test schedule with installation and test procedures shall be furnished prior to installation of the equipment.

- B. All submittal requirements as specified in related Sections shall apply to the Work described herein.

1.04 REFERENCE STANDARDS

- A. Design, manufacture, and assembly of elements of the equipment specified herein shall be in accordance with, but not limited to, published standards of the following as applicable:
 1. Anti-Friction Bearing Manufacturer's Association (AFBMA)
 2. American Gear Manufacturer's Association (AGMA)
 3. American Institute of Steel Construction (AISC)
 4. American Iron and Steel Institute (AISI)
 5. American National Standards Institute (ANSI)
 6. American Society of Mechanical Engineers (ASME)
 7. American Society for Testing Materials (ASTM)
 8. American Welding Society (AWS)
 9. Factory Mutual (FM)
 10. Hydraulic Institute Standards (current edition)
 11. Institute of Electrical and Electronics Engineers (IEEE)
 12. National Electric Code (NEC)
 13. National Electrical Manufacturer's Association (NEMA)
 14. Occupational Safety and Health Administration (OSHA)
 15. Steel Structures Painting Council (SSPC)
 16. Underwriters' Laboratories, Inc. (UL)

1.05 QUALITY ASSURANCE

- A. The equipment specified herein is intended to be progressive cavity pumps for biosolids/wastewater treatment plant sludge of proven ability as manufactured by parties having extensive experience with a minimum of ten (10) years successful operation in the production of such equipment. The equipment furnished shall be designed, constructed and installed in accordance with the best practice and methods
- B. The progressive cavity pumps shall be fabricated as an integral unit by a single Manufacturer to insure compatibility, quality assurance and reliability to the complete unit. The equipment furnished shall be designed, constructed and installed to operate satisfactorily when installed as shown on the Drawings.
- C. All equipment shall be designed and built for 24-hour continuous service at any and all points within the specified range of operation, without overheating, without cavitation, and without excessive vibration or strain.

- D. If submitted equipment requires arrangement differing from that which is indicated on the Drawings or specified, prepare and submit for review complete structural, mechanical, and electrical drawings and equipment lists showing all necessary changes and embodying all special features of equipment proposed. The CONTRACTOR will be responsible for all engineering costs of redesign by an Engineer licensed in the State of Texas, if necessary.
- E. Acceptable Manufacturers:
 - 1. Progressive Cavity Pump: Netzsch Model NM105BO01L06B.2
 - 2. Gear Motor: Nord Model SK972.1F-225SP/4-VW
 - 3. Temperature Controllers: Omron Model E5CSV

1.06 SYSTEM DESCRIPTION

- A. Pumps provided for discharging from the Thickening Centrifuges:
 - 1. General Design Conditions
 - a. The pumps shall be capable of efficiently discharging sludge from the thickening centrifuge units to the mixing tank as specified herein:
 - (i) Solids type: thickened sewage sludge (a mixture of approximately 70% primary sludge and 30% secondary sludge)
 - (ii) Solids content: 6% by weight with a potential maximum value of 7.0%
 - (iii) Solids temperature range: 32 – 113°F
 - (iv) Solids pH range: 5 – 9
 - (v) Specific gravity: Consistent with thickened sewage sludge
 - b. Location requirements: The pumps specified herein shall be installed in the Thickener Complex per the Drawings.
 - c. Site conditions: The equipment specified herein shall be suitable for the site conditions as specified herein:
 - (i) Ambient temperature range: 32 – 105°F (indoor)
 - 2. Pump Design Criteria:
 - a. Number of Pumps: Two (2) Pumps
 - b. Design Point: 180 gpm
 - c. Design Capacity: 64 – 443 gpm
 - d. Design Discharge Pressure: 45 psi
 - e. Pump Operating Speed: 85 rpm
 - f. Pump Maximum Speed: 110 rpm
 - g. Solids Loading Rate: 81,000 to 252,000 pounds/day
 - h. Ambient Environment: Indoors
 - i. Suction Size: Rectangular Inlet, 33.23-inch x 14.57-inch
 - j. Discharge Size: 6 inches, flanged
 - k. Noise requirements per Section 11314 – Noise Requirements and Control
 - l. Equipment Tags:

Thickening Centrifuge Discharge Pumps
HB-TC-SLP-101 Centrifuge No. 1 Discharge Pump

HB-TC-SLP-201 Centrifuge No. 2 Discharge Pump

3. Motor Design Criteria
 - a. Drive: Variable Speed
 - b. Variable Frequency Drives (VFDs) shall be 6-pulse and conform to the requirements of Section 16480 – Motor Control Center.
 - c. Drive Type: Geared Motor
 - d. Drive Configuration: In Line
 - e. Maximum Motor Speed: 1800 rpm (rated speed)
 - f. Motor: 50 HP (maximum), 460 volt, 3 phase, 60 hertz with 1.15 SF with Class F Insulation. Motors shall be non-overloading at any performance point without using any of the service factor.
 - g. Duty: Continuous
 - h. Motors shall meet all requirements of Section 16150 – NEMA Frame Induction Motors, 600V and Below.
4. Refer to Section 17290 – Control Narrative for the pump control description.

1.07 SERVICES OF MANUFACTURER'S REPRESENTATIVE

- A. A pump Manufacturer's factory certified service engineer who has complete knowledge of proper installation, Start-Up, testing, operation and maintenance of the pumping system components as herein specified shall be provided as noted herein and in Section 01730 – Operation and Maintenance Data to test, calibrate and place into service this equipment. Submit qualifications of service engineer for approval.
 1. The factory certified service engineer shall advise, consult and instruct the CONTRACTOR on installation procedures and adjustments and inspect the operators during installation as a condition of acceptance of the Work.
 2. The factory certified service engineer shall be present during all Start-Up and testing operations to make final adjustments as a condition of acceptance of the Work. Refer to Section 11361 – Centrifuge Thickening Equipment for thickening system Start-Up procedures.
- B. A pump Manufacturer approved representative shall be provided to instruct the OWNER's plant operation and maintenance personnel in the proper operation and maintenance (O&M) of the equipment in accordance with the provisions of Section 01730 – Operation and Maintenance Data and as specified herein.
 1. Operating and maintenance manuals shall be furnished to the OWNER as provided in Section 01730 – Operations and Maintenance Data. The manuals shall be prepared specifically for this installation and shall include all required cut sheets, drawings, equipment lists, descriptions, etc. that are required to instruct operating and maintenance personnel unfamiliar with the progressive cavity pump operation and maintenance. In addition to the requirements of Section 01730 – Operation and Maintenance Data, the manuals shall include the following at a minimum:
 - a. Complete parts list, cross-referenced to exploded view assembly drawings.
 - b. Step-by-step disassembly and reassembly instruction.
 - c. Dimensional drawings for all provided components with their respective weights.

2. OWNER training shall be provided and shall include operational instructions to three separate operational teams over a minimum of three separate time periods, Training shall be given at times convenient to the operational team being trained in light of 12-hour operational shifts and duties while on shift. Accordingly, some operational training will have to be conducted during hours outside a normal Monday through Friday, 7:00 am to 3:00 pm EST.
 3. Operational training shall include the following at a minimum:
 - a. Control and operation of all equipment and appurtenances provided with the pumps.
 - b. Trouble shooting guidance.
 - c. Recognizing normal and abnormal operating conditions.
 4. OWNER training shall also include maintenance instructions to one maintenance team. Maintenance training shall be conducted during the hours of 7:00 AM to 3:00 PM EST, Monday through Friday, with exact schedule being determined in light of on-going maintenance team duties. Maintenance training shall include the following, at a minimum:
 - a. Step-by-step assembly and disassembly procedural requirements.
 - b. Replacement part identification and ordering procedures.
 - c. Lubrication procedures.
 - d. Torque and limits switch adjustment.
 - e. Recommended routine maintenance procedures.
 - f. Trouble-shooting and diagnostic procedures.
 - g. Fuse and pilot lamp replacement.
- C. Person-hour requirements tabulated below are exclusive of travel time and do not relieve the CONTRACTOR of obligation to provide sufficient services to place all equipment and appurtenances into satisfactory operation.

Services to be Provided by the Factory Representative	Minimum Number of Trips	Minimum Time On-site Per Trip (Hours)
1. Supervise and assist in the installation of the pumps	2	8
2. Inspect and complete Manufacturer's Certificate of Proper Installation in functional and performance testing(a)	2	8
3. Supervise initial adjustment as necessary and instruct in the Start-Up and Acceptance Testing of pumps(b)	2	8
4. Train OWNER's Operations and Maintenance personnel(c)	1	16

(a) May be done upon completion of Item 1, if acceptable to the ENGINEER.

(b) Instruction may be given upon completion of Item 2, provided that the test is successful and the O&M manuals have been submitted to and reviewed by the ENGINEER.

(c) May be done upon completion of Item 3, provided that the Start-Up and testing is successful.

1.08 SPARE PARTS

- A. All spare parts requirements as specified in related Sections (including Section 11000 – Equipment General Provisions) shall apply to the work described herein.
- B. Each progressive cavity pump shall be furnished with the complete set of the Manufacturer's suggested spare parts including:
 - 1. (2) stators
 - 2. (2) sets of O rings
 - 3. (2) mechanical seals
- C. Provide lubricants (greases and / or oils) necessary to maintain each pump for one (1) year of operation.

1.09 DELIVERY, STORAGE AND HANDLING

- A. All parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment unit installation is completed and the equipment is ready for operation.
- B. Equipment shall be handled and stored in accordance with the Manufacturer's instructions. None of the components of the equipment shall be dropped and all the components shall be examined before installation. No items shall be installed which are found to be defective, and must be repaired to the satisfaction of the ENGINEER.
- C. Factory assembled parts and components shall not be dismantled for shipment or storage unless recommended by the Manufacturer in writing to the ENGINEER.
- D. The finished surfaces of all exposed flanges shall be protected by wooden or equivalent blank flanges, strongly built and securely bolted.
- E. Finished iron or steel surfaces not factory painted shall be properly protected to prevent rust and corrosion.
- F. No shipment shall be made until approved by the ENGINEER in writing.

PART 2 PRODUCTS

2.01 PROGRESSIVE CAVITY PUMPS

- A. Pump Material and Construction
 - 1. The pumps shall be of heavy-duty, positive displacement, progressive cavity-type. They shall be single stage, employing elongated rotor/stator geometry.
 - 2. The pumping shall be closed coupled. The coupling rod shall be an auger design.
 - 3. The extension shaft material shall be AISI 420 – Steel.
 - 4. The coupling rod material shall be 316 stainless steel.
 - 5. All units will come mounted to a carbon steel base plate with corrosion resistant enamel coating.

6. The suction and discharge casings of the pump shall be cast iron or fabricated steel. The suction casing shall incorporate two rectangular inspection ports on opposing sides to permit access to the suction housing interior without disconnecting piping.
7. The rotor shall be constructed of SAE 4140 VCP chrome plated steel. It shall be removable and not attached to a ball joint requiring pump removal. The rotor shall be replaceable without dismantling the pump flanges or associated piping.
8. No special tools or adherence to any fastener torque setting shall be required for replacement of the rotor.
9. The rotor head shall not be a component of a universal joint and shall include provision so that a rotor replacement does not require the disassembly of either universal joint.
10. Each universal joint shall be covered with a stainless steel joint protector and shall be pin type with replaceable bushings. The universal joint shall be rated for a minimum 10,000 hours service life under maximum flow and pressure conditions.
11. The stator shall be a two piece stator, with both pieces identical or split stator casing with retensioning device. The stator shall be replaceable without dismantling the pump suction or discharge piping, disconnection of the pump flanges, or removal of the rotor. Stator designs that, for replacement, require pulling of the pump, disconnection of any pump flange or removal of the rotor shall not be allowed.
12. The stator shall incorporate a re-tensioning feature that allows external adjustments of the compression fit between the stator and rotor to compensate for normal wear.
13. The stator material shall be NEMOLAST® S61L (Buna).
14. No special tools or adherence to any fastener torque setting shall be required for either the replacement or re-tensioning of the stator.
15. The drive shaft shall be of one-piece construction through the shaft seal area, constructed of 316 stainless steel identical to the rotor.
16. The mechanical seal materials shall be 316 stainless steel metals and Viton elastomers. Silicon carbide shall be used for both mechanical seal faces. The mechanical seal casing shall be 316 stainless steel.
17. Bearings, located in the gearbox, shall be designed for a minimum 100,000 hours B-10 life.
18. Gearboxes shall be manufactured by Nord with a minimum service factor of 1.5 and a minimum thrust load capability of 150% of actual thrust. Design duty conditions for gearbox have a minimum bearing L-10 of 100,000 hours.
19. A connection rod shall connect the pin joints of the drive shaft and the rotor. It shall be constructed of 316 stainless steel, designed to maintain maximum angularity of 3 degrees.
20. All flanged connections shall be raised face flanges with bolt hole dimensions and spacing to ANSI Standards. All flanges shall be ANSI 150 lb.
21. A cast iron or corrosion resistant steel base shall be connected to the factory-mounted pump and drive unit. The unit shall be factory aligned on the base prior to shipment.
22. A stainless steel nameplate shall be attached to the pump unit per Section 11100 – Pumps, General giving the Manufacturer's model and serial number, rated capacity, head, speed and all other pertinent data.
23. The stators for each pump shall be fitted with a sensor sleeve and thermistor sensor. A controller shall also be provided and shall be installed in the Control Panel. The controller shall monitor the stator temperature and activate a shutdown and alarm

sequence if the stator temperature reaches the adjustable limit on the controller. The controller shall include a manual local and remote reset function. Input to the controller shall be 1x115VAC/60 Hz.

24. The progressive cavity pumps shall be supplied with a silicone-filled isolation ring with a dual mounted gauge and single point pressure switch. The pressure ranges for the switch and gauge shall be selected specifically for each specified service. The isolation ring shall be mounted between ANSI flanges, be sized according to the discharge pipe as shown on the plans, and be constructed with a carbon steel body and fittings with a Buna N sleeve. The switch shall be SPDT, NEMA 4. High pressure signal shall be wired to the Control Panel.
25. CONTRACTOR provided discharge hopper shall be 316 stainless steel.

B. Variable frequency drives (VFDs): See Division 16 – Electrical.

1. Pumps shall be constant torque type. The pump Manufacturer shall be responsible for the provision of the fixed reduction between the motor and pump. The reduction ratio shall be that required to operate the pump at its maximum operating speed when the motor is operating at its nominal rated full speed.

2.02 PUMP CONTROLS

- A. Pump controls shall be housed in the corresponding centrifuge control panel (e.g., Thickener Discharge Pump HB-TC-SLP-101 controls are housed in the Centrifuge HB-TC-CTF-100 control panel). All controls necessary for the full automatic operation shall be provided as a component of the discharge pump equipment.

2.03 PAINTING

- A. Equipment, frames, baseplates, appurtenances, etc., shall receive surface preparation, prime coating, and one finish coating in the factory prior to shipment in accordance with applicable requirements of Section 09900 – Painting. The CONTRACTOR shall apply a second finish coating in the field to all valves and piping, and touchup paint to the equipment.
- B. Machined, polished, and non-ferrous surfaces shall be coated with corrosion prevention compound.
- C. The following paint matches the previously installed three (3) progressive cavity pumps and is provided for informational purposes. Contractor shall match paint colors.
1. Paint System:
 - a. Two-Part/International Deep Base Gray (Intergard 345) (NPA # NIL657293)
 - b. Two-Part/International Deep Base Green (Intergard 345) (NPA # NIL657292)
 2. Physical Data:
 - a. Primer Type: Surface Tolerant Epoxy
 - b. Volume Solids-Primer: 70%
 3. Application:
 - a. Method – Primer: Conventional Air Spray
 - b. Thinner – Primer: International (#GTA415/1) (NPA # NIL656501)
 - c. Drying Time – Primer: Touch Dry / 90 Minutes, Hard Dry / 7 Hours

PART 3 EXECUTION

3.01 INSTALLATION

- A. All equipment and accessories shall be installed in accordance with the Manufacturer's written recommendations, as approved by the ENGINEER, and as shown on the Drawings. Mount systems as indicated.
- B. The CONTRACTOR shall be responsible for installing equipment that the Manufacturer could not ship assembled as an integral part of the system due to shipping restrictions. These items shall be identified on the Manufacturer's approval drawings.
- C. Do not begin fabrication or erection prior to submittal approval.
- D. The pump Manufacturer's factory certified service engineer shall inspect the complete installation and provide written certification stating that the installation of the equipment is satisfactory. The certification must also indicate the equipment is ready for operation and that the operating personnel have been suitably instructed in the operation, lubrication and care of the system.

3.02 FACTORY TESTING

- A. Factory testing of the pumping units shall be conducted in accordance with Hydraulic Institute Standards.
- B. Functional Test: Perform Manufacturer's recommended functional testing, including standard tests, as follows:
 - 1. Conduct performance testing on each pump and submit the total head, pressure, line amps, and speed of each pump unit.
 - 2. Complete performance testing at design flow and design pressure as specified.
 - 3. Submit all testing results and pump curves as specified. Pump curves shall include head, capacity and brake horsepower for each pump supplied.

3.03 FIELD INSPECTION, PERFORMANCE TESTING, AND START-UP

- A. Prior to Start-Up, all equipment shall be inspected by the Manufacturer's certified service engineer for proper alignment, quiet operation, proper connection and satisfactory performance. Provide written certification from the certified service engineer that the equipment is performing and operating as intended and is approved for Start-Up.
- B. Start-Up shall be performed per Section 11361 – Centrifuge Thickening Equipment.
- C. Any component parts which are damaged as a result of Performance Testing, Start-Up or which fail to meet the requirements of these Specifications shall be replaced, reinstalled and re-tested at the CONTRACTOR's expense.

3.04 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered

subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 11323
ROTARY LOBE PUMPS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The work requires that the Centrifuge Manufacturer accept responsibility for furnishing a complete thickening system as indicated in the Specifications and on the Drawings but without altering the CONTRACTOR's responsibilities under Contract Documents.
- B. The CONTRACTOR shall perform the demolition of the existing progressive cavity feed pumps as shown on the Drawings. The CONTRACTOR shall furnish labor and materials as required for the storage and installation of the proposed rotary lobe feed pumps.
- C. The CONTRACTOR shall install and place in satisfactory operation two (2) rotary lobe feed pumps, equipped complete, as shown on the Drawings and as specified herein. All necessary and desirable accessory equipment and auxiliaries, whether specifically mentioned herein or not, shall be furnished and installed as required for an installation incorporating the highest standards for this type of equipment.
- D. The Centrifuge Manufacturer shall have responsibility to provide a complete and functional thickening system that includes the following components in addition to the rotary lobe feed pumps. The Centrifuge Manufacturer shall be responsible to provide all equipment and coordinate all controls so the equipment operates as a complete system as intended and described in Section 17920 – Control Narrative:
 - 1. Section 11318 – Progressive Cavity Pumps
 - 2. Section 11330 – Macerators
 - 3. Section 11361 – Centrifuge Thickening Equipment
 - 4. Section 17520 – Instruments
 - 5. Section 17400 – Instrument Panels
 - 6. Other controls and appurtenances needed for a complete and functional system

1.02 RELATED WORK

- A. Drawings and all provisions of the Contract Documents shall apply to this Section, including:
 - 1. Division 1 – General Requirements
 - 2. Division 3 – Concrete
 - 3. Division 5 – Metals
 - 4. Division 9 – Finishes
 - 5. Division 11 – Equipment
 - 6. Division 15 – Mechanical
 - 7. Division 16 – Electrical
 - 8. Division 17 – Instrumentation

1.03 SUBMITTALS

- A. Submit shop drawings and product data in accordance with Section 01300 – Submittals, showing materials of construction, details of fabrication, and installation of items furnished herein. This information shall include, but is not be limited to:
1. Complete fabrication, assembly, and installation drawings, showing the Manufacturer's dimensions, weights, and loadings, and descriptive information in sufficient detail to show the kind, size, weight, arrangements, operation, component materials and devices, external connections, anchorages and supports required, performance characteristics, and dimensions needed for installation.
 2. Detailed data covering materials used, parts, instrumentation devices and other accessories forming a part of the equipment furnished will be submitted for review.
 3. Certified shop and erection drawings showing all important details of construction, dimensions and anchor bolt locations.
 4. Manufacturer's installation instructions.
 5. Detailed cross-section of pump, seals and motor indicating detailed features and materials of construction.
 6. Performance curves for each pump at the design point(s) indicated for the system head herein. Curves shall cover range from shutoff to at least 150% of design flow rates and shall be submitted for the following parameters as a function of capacity at design temperature.
 - a. Discharge pressure
 - b. Required NPSH
 - c. Speed
 - d. Efficiency
 - e. Required brake horsepower
 7. Electrical data including control wiring. Electrical requirements, schematic diagrams and details of components including enclosures.
 8. Complete motor and drive data.
 9. Detailed layout drawing of the control wiring termination information in the Centrifuge Control Panel.
 10. Product data on all electrical and control components defining functional requirements and construction.
 11. Painting methods and material data.
 12. Certificate of Compliance or complete list of all deviations from the Drawings and Specifications.
 13. Manufacturer's warranty agreement and special guarantee in compliance with the Contract Documents.
 14. Special shipping, storage and protection, and handling instructions.
 15. Manufacturer's recommended spare parts.
 16. Operation and maintenance manuals in accordance with Section 01730 – Operation and Maintenance Data.
 17. Factory certified service engineer or local Field Service Representative as required herein.

18. Test procedures, results, reports and certifications. Prior to shipment of the equipment from the Manufacturer's facility, submit the following certified tests to the ENGINEER for approval:
 - a. Factory run performance tests in accordance with the standards of the Hydraulic Institute. Characteristics of pumps may have a tolerance of plus 10% of rated capacity at rated head or plus 5% of rated head at rated capacity. No minus tolerances will be acceptable. CONTRACTOR to give the ENGINEER notice seven (7) days prior to performance test date.
 19. Manufacturer's Installation Instruction and Certificates for Proper Installation which states that the equipment meets all the design and performance requirements herein.
 20. Installation, Start-Up, and test schedule with installation and test procedures shall be furnished prior to installation of the equipment.
- B. All submittal requirements as specified in related Sections shall apply to the Work described herein.

1.04 REFERENCE STANDARDS

- A. Design, manufacture and assembly of elements of the equipment specified herein shall be in accordance with, but not limited to, published standards of the following as applicable:
1. American Bearing Manufacturers Association (ABMA)
 2. American Institute of Steel Construction (AISC)
 3. American Iron and Steel Institute (AISI), AISI 4140 and 8620
 4. Anti-Friction Bearing Manufacturer's Association (AFBMA)
 5. American Gear Manufacturer's Association (AGMA)
 6. American National Standards Institute (ANSI)
 7. American Society of Mechanical Engineers (ASME)
 8. American Society for Testing and Materials (ASTM):
 - a. ASTM A48-76 – Specification for Gray Iron Castings
 - b. ASTM A536 – Specification for Ductile Iron Castings
 9. American Welding Society (AWS)
 10. Factory Mutual (FM)
 11. Hydraulic Institute Standards, Current Edition (HI)
 12. Institute of Electrical and Electronics Engineers (IEEE)
 13. National Electric Code (NEC)
 14. National Electrical Manufacturers Association (NEMA)
 15. Occupational Safety and Health Administration (OSHA)
 16. Steel Structures Painting Council (SSPC)
 17. Underwriters' Laboratories, Inc. (UL)

1.05 QUALITY ASSURANCE

- A. The equipment specified herein is intended to be positive displacement, rotary lobe pumps for biosolids / wastewater treatment plant sludge of proven ability as

manufactured by parties having extensive experience with a minimum of ten (10) years successful operation in the production of such equipment. The furnished equipment shall be designed, constructed and installed in accordance with the best practice and methods and shall operate satisfactorily when installed as shown on the Drawings.

- B. The rotary lobe pumps shall be fabricated as an integral unit by a single Manufacturer to insure compatibility, quality assurance and reliability to the complete unit. The equipment furnished shall be designed, constructed and installed to operate satisfactorily when installed as shown on the Drawings.
- C. All equipment shall be designed and built for 24-hour continuous service at any and all points within the specified range of operation, without overheating, without cavitation and without excessive vibration or strain.
- D. The pumping units required herein shall be complete. All parts shall be so designed and proportioned as to have liberal strength, stability and stiffness and to be especially adapted for the service to be performed. Ample room for inspection, repairs and adjustments shall be provided. There shall be no significant change in vibration and noise level over the entire listed range of operating conditions of the pumping system. Pump shall be fully reversible such that both ports can be the suction and the rotor lobes are capable of dual rotation. The pumps shall be designed to temporarily run dry and to operate in either direction without damage to the pump or its internals. To prolong dry run time, goose-neck or S-shape flanges shall be provided to trap fluid. Pumps must have a design option to integrate a dry running protection in the rotor case in terms of an unlikely, very long period of dry running.
- E. All working parts of the pumps and motors, such as bearings, wearing rings, shaft, sleeves, etc., shall be standard dimensions built to limit gauges or formed to templates, such that parts will be interchangeable between like units and such that the OWNER may, at any time in the future, obtain replacement and repair parts for those furnished in the original machines.
- F. All lubrication fittings shall be brought to the outside of all equipment so that they are readily accessible from the outside without the necessity of removing covers, plates, housings or guards.
- G. Motor sizing shall provide a minimum of 20% reserve horsepower as evidenced by the specific requirements at maximum design condition on the certified performance curve.
- H. The pumps shall be designed and constructed in accordance with standards of the Hydraulic Institute. The efficiency of the pumps, when operating under conditions of the specified capacities and heads, shall be as near peak efficiency as practical.
- I. If submitted equipment requires arrangement differing from that which is indicated on the Drawings or specified, prepare and submit for review complete structural, mechanical and electrical drawings and equipment lists showing all necessary changes and embodying all special features of equipment proposed. The CONTRACTOR will be responsible for all engineering costs of redesign by an Engineer licensed in the State of Texas, if necessary.

J. Acceptable Manufacturers:

1. Rotary Lobe Pump: Boerger Model FL 776

- a. Motor (40hp, 1770rpm, 3P, 60Hz, 230/460V, 324TC, TEFC, F1): Baldor Model CEC84110T-4 CUS
 - (i) Enclosure – Severe duty IEEE 841-TEFC
 - (ii) M4G – Conduit Box for 120V Heater
 - (iii) M21A – 120V Space Heater
- b. Coupling (48mm x 65mm, galvanized steel, in-line): KTR Model Rotex 38 GJL
- c. Gear Reduction (530rpm, 3.3:1): Nord Model SK62-320TC
- d. Gear casing (FL, 0.6025): Model A10008
- e. Gear casing cover (FL, 0.6025, top or bottom shaft): Model A10109
- f. Pump casing cover (FL, 0.7040): Model B31008
- g. Cover protection plate (FL, 1.4571): Model B31028
- h. Casing protection plate (FL, 1.4571): Model B31048
- i. Pump casing (FL 776, MIP, 0.6025): Model B40480
- j. Radial casing liner (FL 776, 1.4571): Model B41220
- k. Clamping part (FL 776/FLA 1540, 1.4571, hydrodynamically, optimized shape): Model B41351
- l. Cover disk (FL, 1.7225): Model C70804
- m. Mechanical seal (CL/FL, Duronit/NBR): Model D35008
- n. Holding bush with thread (FL, 1.0503): Model D35114
- o. Stationary holding bush (FL, 1.0503): Model D35218
- p. Gear oil (mineral, BP Energol GR-XP 220): Model DAD.034
- q. Gear wheel (FL, 1.7225): Model E12104
- r. Sealing washer (A33 x 39 x 2, Copper, DIN 7603): Model K22108
- s. Sealing washer (33 x 39 x 2, Tesnit BA 202, both sides, both sides graphite coated, Cellulose/NBR): Model K22208
- t. Sealing washer (A21 x 25 x 1.5, Copper, DIN 7603) Model K22408

1.06 SYSTEM DESCRIPTION

A. Pumps provided for feeding the Thickening Centrifuges:

1. General Design Conditions

- a. The pumps shall be capable of efficiently feeding sludge to the thickening centrifuge units as specified herein:
 - (i) Sludge type: raw sewage sludge (a mixture of approximately 70% primary sludge and 30% secondary sludge)
 - (ii) Solids content: 1.0 – 2.5% by weight with a potential maximum value of 3.5%
 - (iii) Solids temperature range: 32 – 113°F
 - (iv) Solids pH range: 5 – 9
 - (v) Specific gravity: Consistent with sewage sludge
- b. Location requirements: The pumps specified herein shall be installed in the Thickener Complex per the Drawings.

- c. Site conditions: The equipment specified herein shall be suitable for the site conditions as specified herein:
 - (i) Ambient temperature range: 32 – 105°F (indoor)
- 2. Pump Design Criteria:
 - a. Pump Type: Heavy-duty rotary lobe
 - b. Number of Pumps: Two (2) Pumps
 - c. Design Point: 450 gpm
 - d. Maximum Capacity: 1000 gpm
 - e. NPSHa: 8.7 ft (minimum)
 - f. Differential Pressure: 30.0 psi
 - g. Minimum Displacement: 226.2 gallons / 100 revolutions
 - h. Maximum Pump Speed: 490 rpm
 - i. Discharge Pressure: 33.4 psi
 - j. Suction Condition: Flooded
 - k. Operating Mode: Continuous
 - l. Ambient Environment: Indoors
 - m. Flanges: 316L Stainless Steel
 - n. Suction Size: 8" ANSI 150lb
 - o. Discharge Size: 8" ANSI 150lb
 - p. Noise requirements per Section 11314 – Noise Requirements and Control
 - q. Equipment tags:
 - Thickening Centrifuge Feed Pumps
 - HB-TC-SLP-100 Centrifuge No. 1 Feed Pump
 - HB-TC-SLP-200 Centrifuge No. 2 Feed Pump
- 3. Motor Design Criteria
 - a. Listed under Paragraph 1.05.J.
- 4. Refer to Section 17920 – Control Narrative for the pump control description.

1.07 SERVICES OF MANUFACTURER'S REPRESENTATIVE

- A. A pump Manufacturer's factory certified service engineer who has complete knowledge of proper installation, Start-Up, testing, operation and maintenance of the pumping system components as herein specified shall be provided as noted herein and in Section 01730 – Operation and Maintenance Data to test, calibrate and place into service this equipment. Submit qualifications of service engineer for approval.
 - 1. The factory certified service engineer shall advise, consult and instruct the CONTRACTOR on installation procedures and adjustments and inspect the operators during installation as a condition of acceptance of the Work.
 - 2. The factory certified service engineer shall be present during all Start-Up and testing operations to make final adjustments as a condition of acceptance of the Work. Refer to Section 11361– Centrifuge Thickening Equipment for thickening system Start-Up procedures.

- B. A pump Manufacturer approved representative shall be provided to instruct the OWNER's plant operation and maintenance personnel in the proper operation and maintenance (O&M) of the equipment in accordance with the provisions of Section 01730 – Operation and Maintenance Data and as specified herein.
1. Operating and maintenance manuals shall be furnished to the OWNER as provided in Section 01730 – Operations and Maintenance Data. The manuals shall be prepared specifically for this installation and shall include all required cut sheets, drawings, equipment lists, descriptions, etc. that are required to instruct operating and maintenance personnel unfamiliar with the positive displacement, rotary lobe pump operation and maintenance. In addition to the requirements of Section 01730 – Operation and Maintenance Data, the manuals shall include the following at a minimum:
 - a. Complete parts list, cross-referenced to exploded view assembly drawings.
 - b. Step-by-step disassembly and reassembly instruction.
 - c. Dimensional drawings for all provided components with their respective weights.
 2. OWNER training shall be provided and shall include operational instructions to three (3) separate operational teams over a minimum of three (3) separate time periods. Training shall be given at times convenient to the operational team being trained in light of 12-hour operational shifts and duties while on shift. Accordingly, some operational training will have to be conducted during hours outside a normal Monday through Friday, 7:00 AM to 3:00 PM CST. Operational training shall include the following at a minimum:
 - a. Control and operation of all equipment and appurtenances provided with the pumps.
 - b. Trouble-shooting guidance.
 - c. Recognizing normal and abnormal operating conditions.
 3. OWNER training shall also include maintenance instructions to one maintenance team. Maintenance training shall be conducted during the hours of 7:00 AM to 3:00 PM CST, Monday through Friday, with exact schedule being determined in light of on-going maintenance team duties. Maintenance training shall include the following, at a minimum:
 - a. Step-by-step assembly and disassembly procedural requirements.
 - b. Replacement part identification and ordering procedures.
 - c. Lubrication procedures.
 - d. Torque and limits switch adjustment.
 - e. Recommended routine maintenance procedures.
 - f. Trouble-shooting and diagnostic procedures.

- C. Person-hour requirements tabulated below are exclusive of travel time and do not relieve the CONTRACTOR of obligation to provide sufficient services to place all equipment and appurtenances into satisfactory operation.

Services to be Provided by the Factory Representative	Minimum Number of Trips	Minimum Time On-site Per Trip (Hours)
1. Supervise and assist in the installation of the pumps	2	8
2. Inspect and complete Manufacturer's Certificate of Proper Installation in functional and performance testing ^(a)	2	8
3. Supervise initial adjustment as necessary, instruct in the Start-Up and testing of pumps, and train OWNER's Operations and Maintenance personnel ^(b)	2	8
4. Train OWNER's Operations and Maintenance personnel ^(c)	1	16

^(a) May be done upon completion of Item 1, if acceptable to the ENGINEER.

^(b) Instruction may be given upon completion of Item 2, provided that the test is successful and the O&M manuals have been submitted to and reviewed by the ENGINEER.

^(c) May be done upon completion of Item 3, provided that the Start-Up and testing is successful.

1.08 SPARE PARTS

- A. All spare parts requirements as specified in related Sections (including Section 11000 – Equipment General Provisions) shall apply to the work described herein.
- B. Each rotary lobe pump shall be furnished with the complete set of the Manufacturer's suggested spare parts, including but not limited to, the following:
1. One (1) set of mechanical seals and O-rings.
 2. One (1) set of lobes and o-rings.
 3. One (1) set of gearcase lip seals.
 4. One (1) set of radial liners (if provided).
 5. One (1) set of special tools.
 6. One (1) set of rear wear plates for each pump model.
 7. One (1) front wear plates or front hinged front cover for each model.
 8. One (1) set of radial wear plates or two radial housing sections for each model pump.
- C. All working parts of the pumps and motors, such as bearings, wearing rings, shaft, sleeves, etc., shall be standard dimensions built to limit gauges or formed to templates, such that parts will be interchangeable between like units and such that the OWNER may, at any time, obtain replacement and repair parts for those furnished in the original machines.

- D. Provide lubricants (greases and / or oils) necessary to maintain each pump for one (1) year of operation.
 - 1. Intermediate Chamber: Mobil DTE 10 Excel 68
 - 2. Timing Gear: Mobilgear 600 XP 220

1.09 DELIVERY, STORAGE AND HANDLING

- A. All parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment unit installation is completed and the equipment is ready for operation.
- B. Equipment shall be handled and stored in accordance with the Manufacturer's instructions. None of the components of the equipment shall be dropped and all the components shall be examined before installation. No items shall be installed which are found to be defective and must be repaired to the satisfaction of the ENGINEER.
- C. Factory assembled parts and components shall not be dismantled for shipment or storage unless recommended by the Manufacturer in writing to the ENGINEER.
- D. The finished surfaces of all exposed flanges shall be protected by wooden or equivalent blank flanges, strongly built and securely bolted.
- E. Finished iron or steel surfaces not factory painted shall be properly protected to prevent rust and corrosion.
- F. No shipment shall be made until approved by the ENGINEER in writing.

PART 2 PRODUCTS

2.01 ROTARY LOBE PUMPS

- A. General
 - 1. The ratio of the axial length of the lobe as compared to the lobe diameter (length / diameter) shall not exceed 1.0.
 - 2. All fluid-wetted parts including the mechanical seal shall be replaceable through the quick release front cover without disassembly of coupling, drive unit, rotor case or the pipe system.
 - 3. The pumps shall be designed to temporarily run dry and to operate in either direction. Oil-quench for protection of the mechanical seal is mandatory. Seal water flush systems are not acceptable.
 - 4. The pumps shall be designed with a Gearbox Security System (GSS), an open gap between pump and pump gear box in order to allow sludge to leak onto the floor and not into the timing gear box in the event of shaft seal failure.
 - 5. Oil drain of gearbox and intermediate chamber shall be easily accessible with side mounted drain screw. Oil drain under the pump is not acceptable.
 - 6. The rotor / shaft connection shall be oil-lubricated fed by an intermediate chamber and shall not come in contact with the pumped fluid.
 - 7. The suction and discharge of the rotary lobe pump shall be fabricated in a 316 stainless steel "gooseneck" configuration per the Drawings to ensure product will stay in the pump for startup.

B. Pump Construction

1. The pump casing shall be manufactured in a single block construction (Cast iron ASTM A48 grade 40, Brinell Hardness: 264 Brinell). Multiple Piece design pump casings held together by screw connections are not acceptable.
2. Pumps without replaceable radial housing sections shall be provided with radial wear plates. The removable wear plates shall be abrasion-resistant wear plates that will protect the wear of the rotor case. The wear plates must be easy to remove and fixed / bolted at the inlet and outlet of the rotor case.
3. Pumps must have rear and front wear plates. The rear of the pump casing and the front cover shall be protected with replaceable wear plates in 316 stainless steel. The front cover protection plate shall be reversible. The pump casing shall be equipped with radial pump casing protection plates, which are less expensive and will eliminate the pump casing as a spare part for reduction of the Life Cycle Costs of the pump unit. Pump casings without radial liners are not acceptable. The front and rear wear plate shall be easy to remove and easily accessible. Fixing screws must not be in the swept surface of the rotor.
4. The quick release cover shall be held in place by four eye nuts at the housing, thus maintaining the repeatable relative position. The stationary threaded studs shall keep the front cover on the same level as the pump casing in the process of opening the pump for easy handling.
5. The pump shall be fitted with a pair of intermeshing rotors with a minimum of three lobes in helical low pulse design, in order to give lowest possible pulsation and thus safe operation for the complete sludge handling process. Rotor tips shall consist of a cast iron core with abrasion-resistant Buna N OR heavy ductile iron core coated with abrasion-resistant elastomer. The elastomeric coated rotors shall be guaranteed against "bonding failure" otherwise known as delamination. The pump Manufacturer shall verify rotor material and hardness are suitable for the application. Rotors shall be keyed to the shaft with a cylindrical bore. The rotors shall be end-mounted on the shafts and held precisely in the radial position. This shall ensure the positive positioning of the rotors on the shaft as well as provide precise intermeshing clearances around the rotors. The rotors shall be axially locked into position.
6. Pumps without replaceable axial and radial liners shall provide 316 stainless steel casing with all fasteners in 316 stainless steel.
7. The pump head flanges shall provide a smooth transition from circular port to connections at the flanges, to a full width rectangular port at the rotor chamber, with a greater cross sectional area than at the flanged port connection, to allow for unimpeded passage of solids.
8. The shafts shall be non-sludge-wetted. The motor driven shaft shall be either the upper shaft or lower shaft as determined by the centerline height of the driver. The rotor / shaft connection shall be lubricated with quench fluid of the intermediate chamber. Each shaft shall be supported by heavy-duty cylindrical and roller bearings. Synchronization of shafts shall be done by hardened and ground high precision timing gears. Sludge wetted rotor / shaft connections are not acceptable. The shafts shall be constructed from AISI 4140 or carbon steel and be appropriately sized and heat treated to ensure a smooth operation and concentric positioning on the rotors. The length of shafts must be as short as possible in order to avoid any shaft deflection. Long shaft overhang at pump head side is not acceptable.

9. The pumps shall be fitted with maintenance-free, quenched mechanical seals with abrasive resistant Duronit seal faces or silicon carbide to tungsten carbide seal surfaces, elastomer in NBR quality. The seals shall be operating in a common oil-filled intermediate chamber (quench for lubrication and cooling). Purge or oil flush systems for the seals are not acceptable. The rotating holding bush shall be locked in a fixed radial position by a keyway that also holds the rotor in the radial position. Seal designs that open during rotor replacement are not acceptable. No sleeves shall be necessary for the mechanical seal set up. Design of the pump shall allow removal and replacement of the seal via the front cover.
10. Shaft seals must be of heavy duty simple and robust design in order to allow high operation safety and easy servicing. Shaft seals must be front loading seals and internal mounted. Designs requiring the removal of the rotor case for seal replacement will not be acceptable.
11. Bearings and timing gear shall be located in a common oil-filled cast iron gearbox, fitted with a built in sight glass to monitor oil level. The bearings must be positioned on either side of the timing gears in order to give the best shaft support. The timing gear shall maintain non-contact between the rotors. Bearing life to be designed for L-10 bearing life rating of 100,000 hours at design conditions.
12. Pumps without oil lubricated bearings shall have bearing isolators. The bearings shall be completely protected from water or sludge by grease packed 316 stainless steel labyrinth bearing isolators providing full protection with the pump either operating or idle. The gearcase wall adjacent to the rotor case shall be sealed from water or sludge penetration by a pair of non-wearing 316 stainless steel AISI 316, grease filled, labyrinth-bearing isolators.
13. Pumps without oil lubricated bearings shall have a gear case constructed of 316 stainless steel and incorporate a separate oil reservoir for the bearings of each shaft to ensure adequate lubrication at low running speed. Sealed expansion chambers shall be used for vent caps preventing any air transfer to and from the gearbox. The design shall be a gear case security system (GSS) or open gap for highest possible reliability.
14. Furnish a flexible, forged steel coupling of an approved type for connecting the pump, reducer and motor. Provide couplings of the proper size to transmit the power required to drive the pump under all conditions of operation. OSHA approved guards shall be furnished over all couplings.
15. A 316 stainless steel nameplate shall be attached to the pump unit per Section 11100 – Pumps, General giving the Manufacturer's model and serial number, rated capacity, head, speed and all other pertinent data.
16. Suction and discharge connections shall be 316 stainless steel.

C. Variable frequency drives (VFDs): See Division 16 – Electrical.

1. Pumps shall be constant torque type. The pump Manufacturer shall be responsible for the provision of the fixed reduction between the motor and pump. The reduction ratio shall be that required to operate the pump at its maximum operating speed when the motor is operating at its nominal rated full speed.

2.02 PUMP CONTROLS

- A. Pump controls shall be housed in the corresponding centrifuge control panel (e.g., Thickener Discharge Pump HB-TC-SLP-100 controls are housed in the Centrifuge HB-

TC-CTF-100 control panel). All controls necessary for the full automatic operation shall be provided as a component of the feed pump equipment.

2.03 PAINTING

- A. Equipment, frames, baseplates, appurtenances, etc., shall receive surface preparation, prime coating and one finish coating in the factory prior to shipment in accordance with applicable requirements of Section 09900 – Painting. The CONTRACTOR shall apply a second finish coating in the field to all valves and piping, and touchup paint to the equipment. Colors shall be selected by the OWNER during submittal reviews. The CONTRACTOR shall provide a manufacturer's standard factory applied epoxy coating to pump, reducer, motor, base and coupling guards.
- B. Machined, polished, and non-ferrous surfaces shall be coated with corrosion prevention compound.
- C. Acceptable Manufacturers:
 - 1. Borger: 1 coat of 80µm C1-H or C2-L – 1 x PG2
 - 2. Osnatol: Osnapox Z single component primer (color) – Osnasol thinner special 0089-00580 and Osnasol thinner PU 0089-00200
 - 3. Osnatol: Osnacryl PUR paint G (color shade) - mixing by 8:1 by weight with Osnasol thinner PU (03089-00200) and Osnapur hardener AL 17 (0041-11963)

PART 3 EXECUTION

3.01 INSTALLATION

- A. All equipment and accessories shall be installed in accordance with the Manufacturer's written recommendations, as approved by the ENGINEER, and as shown on the Drawings. Mount systems as indicated.
- B. The CONTRACTOR shall be responsible for installing equipment that the Manufacturer could not ship assembled as an integral part of the system due to shipping restrictions. These items shall be identified on the Manufacturer's approval drawings.
- C. Do not begin fabrication or erection prior to submittal approval.
- D. The pump Manufacturer's factory certified service engineer shall inspect the complete installation and provide written certification stating that the installation of the equipment is satisfactory. The certification must also indicate the equipment is ready for operation and that the operating personnel have been suitably instructed in the operation, lubrication and care of the system.
- E. Each pump shall be arranged in an in-line arrangement as shown on the Drawings.
- F. Factory mount pump and motor, coupled together, on a common groutable steel base, properly braced to form a rigid support for the entire unit. Factory align the units on the base prior to shipment. Final alignment shall be performed in field following base grouting and piping connections.

3.02 FACTORY TESTING

- A. Factory testing of the pumping units shall be conducted in accordance with Hydraulic Institute Standards. All pumps shall be tested complete with drives at the Pump Manufacturer facility.
- B. All rotary lobe pumps shall be tested at full speed and complete staging through the specified range of flow, and head / capacity / efficiency curves plotted at maximum output speed.
- C. If any pump tested fails to meet any specific requirement, it shall be modified until it meets all specification requirements. If any pump tested fails to meet the efficiency requirements at any of the listed flow or head conditions listed and all reasonable attempts to correct the inefficiency are unsuccessful, the pump(s) shall be replaced with unit(s) which meet the specified requirements.
- D. Functional Test: Perform Manufacturer's recommended functional testing, including standard tests, as follows:
 - 1. Conduct performance testing on each pump and submit the total head, pressure, line amps and speed of each pump unit.
 - 2. Complete performance testing at design flow and design pressure as specified.
 - 3. Submit all testing results and pump curves as specified. Pump curves shall include head, capacity and brake horsepower for each pump supplied.

3.03 FIELD QUALITY INSPECTION, PERFORMANCE TESTING, AND START-UP

- A. Prior to Start-Up, all equipment shall be inspected by the Manufacturer's certified service engineer for proper alignment, quiet operation, proper connection and satisfactory performance. Provide written certification from the certified service engineer that the equipment is performing and operating as intended and is approved for Start-Up.
- B. Start-Up shall be performed per Section 11361 – Centrifuge Thickening Equipment.
- C. Any component parts which are damaged as a result of Performance Testing, Start-Up or which fail to meet the requirements of these Specifications shall be replaced, reinstalled and re-tested at the CONTRACTOR's expense.

3.04 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 11330

MACERATORS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The work requires that the Centrifuge Manufacturer accept responsibility for furnishing a complete thickening system as indicated in the Specifications and on the Drawings but without altering the CONTRACTOR's responsibilities under Contract Documents.
- B. The CONTRACTOR shall furnish labor and materials as required for the storage and installation of the proposed macerators.
- C. The CONTRACTOR shall install and place in satisfactory operation two (2) macerators, equipped complete, as shown on the Drawings and as specified herein. All necessary and desirable accessory equipment and auxiliaries, whether specifically mentioned herein or not, shall be furnished and installed as required for an installation incorporating the highest standards for this type of equipment.
- D. The Centrifuge Manufacturer shall have responsibility to provide a complete and functional thickening system that includes the following components in addition to the macerators. The Centrifuge Manufacturer shall be responsible to provide all equipment and coordinate all controls so the equipment operates as a complete system as intended and described in Section 17920 – Control Narrative:
 - 1. Section 11318 – Progressive Cavity Pumps
 - 2. Section 11323 – Rotary Lobe Pumps
 - 3. Section 11361 – Centrifuge Thickening Equipment
 - 4. Section 17520 – Instruments
 - 5. Section 17400 – Instrument Panels
 - 6. Other controls and appurtenances needed for a complete and functional system

1.02 RELATED WORK

- A. Drawings and all provisions of the Contract Documents shall apply to this Section, including:
 - 1. Division 1 – General Requirements
 - 2. Division 5 – Metals
 - 3. Division 9 – Finishes
 - 4. Division 11 – Equipment
 - 5. Division 15 – Mechanical
 - 6. Division 16 – Electrical
 - 7. Division 17 – Instrumentation

1.03 SUBMITTALS

- A. Submit shop drawings and product data in accordance with Section 01300 – Submittals, showing materials of construction, details of fabrication and installation of items furnished herein. This information shall include, but not be limited to:
1. Complete fabrication, assembly, and installation drawings showing the Manufacturer's dimensions, weights, and loadings, and descriptive information in sufficient detail to show the kind, size, weight, arrangements, operation, component materials and devices, external connections, anchorages and supports required, performance characteristics, and dimensions needed for installation.
 2. Detailed data covering materials used, parts, instrumentation devices, functional descriptions and other accessories forming a part of the equipment furnished will be submitted for review.
 3. Certified shop and erection drawings showing all important details of construction, dimensions and anchor bolt locations.
 4. Manufacturer's installation instructions.
 5. Detailed cross-section of macerator and materials of construction.
 6. Painting description and material data.
 7. Provide local control panel drawings. Drawings shall include panel size, layout, schematic diagram, terminal schedule, bill of materials and datasheet for each component.
 8. Control information, including control sequencing.
 9. Certificate of Compliance or complete list of all deviations from the Drawings and Specifications.
 10. Manufacturer's warranty agreement and special guarantee in compliance with the Contract Documents.
 11. Special shipping, storage and protection, and handling instructions.
 12. Manufacturer's recommended spare parts.
 13. Operation and maintenance manuals in accordance with Section 01730 – Operation and Maintenance Data.
 14. Installation, Start-Up and test schedule with installation and test procedures shall be furnished prior to installation of the equipment.
 15. Factory hydrostatic and vibration test results.
 16. Factory certified service engineer or local Field Service Representative as required herein.
 17. Test procedures, results, reports and certifications.
 18. Manufacturer's Installation Instruction and Certificates for Proper Installation which states that the equipment meets all the design and performance requirements of this Section.
- B. All submittal requirements as specified in related Sections shall apply to the Work described herein.

1.04 REFERENCE STANDARDS

- A. Design, manufacture and assembly of elements of the equipment specified herein shall be in accordance with, but not limited to, published standards of the following as applicable:
1. Anti-Friction Bearing Manufacturer's Association (AFBMA)
 2. American Gear Manufacturer's Association (AGMA)
 3. American Institute of Steel Construction (AISC)
 4. American Iron and Steel Institute (AISI)
 5. American National Standards Institute (ANSI)
 6. American Society of Mechanical Engineers (ASME)
 7. American Society for Testing Materials (ASTM)
 8. American Welding Society (AWS)
 9. Factory Mutual (FM)
 10. Hydraulic Institute Standards (current edition)
 11. International Electrotechnical Commission (IEC)
 12. Institute of Electrical and Electronics Engineers (IEEE)
 13. National Electric Code (NEC)
 14. National Electrical Manufacturer's Association (NEMA)
 15. Occupational Safety and Health Administration (OSHA)
 16. Society of Automotive Engineers (SAE)
 17. Steel Structures Painting Council (SSPC)
 18. Underwriters' Laboratories, Inc. (UL)

1.05 QUALITY ASSURANCE

- A. The equipment specified herein is intended to be macerators for biosolids/wastewater treatment plant sludge of proven ability as manufactured by parties having extensive experience with a minimum of five (5) years successful operation in the production of such equipment. The equipment furnished shall be designed, constructed and installed in accordance with the best practice and methods.
- B. The equipment furnished shall be designed, constructed and installed to operate satisfactorily when installed as shown on the Drawings.
- C. The Macerator Manufacturer shall be ISO 9001 certified. The Macerator Manufacturer shall, upon request, provide a list of reference sites of similar equipment for verification by the ENGINEER or at the OWNER's request.
- D. All equipment shall be designed and built for 24-hour continuous service at any and all points within the specified range of operations without overheating, without cavitation and without excessive vibration or strain.
- E. The macerators required herein shall be complete. All parts shall be so designed and proportioned as to have liberal strength, stability and stiffness and to be especially adapted for the service to be performed. Ample room for inspection, repairs and adjustments shall be provided.

- F. All lubrication fittings shall be brought to the outside of all equipment so that they are readily accessible from the outside without the necessity of removing covers, plates, housings or guards.
- G. Motor sizing shall provide a minimum of 20% reserve horsepower as evidenced by the specific requirements at maximum design condition on the certified performance curve.
- H. If submitted equipment requires arrangement differing from that which is indicated on the Drawings or specified, prepare and submit for review complete structural, mechanical and electrical drawings and equipment lists showing all necessary changes and embodying all special features of equipment proposed. The CONTRACTOR will be responsible for all engineering costs of redesign by an Engineer licensed in the State of Texas, if necessary.
- I. Acceptable Manufacturers
 - 1. Macerator: Boerger, LLC Model RR 6000
 - 2. Motor: Baldor (ABB Motors and Mechanical, Inc.) Model CECP83774T-4
 - a. Gear Reducer: Nord Gear Corporation Model SK 3282
 - b. Coupling: KTR Model Rotex 75
 - 3. Control Panel: Boerger Model S480 3Ø TR
 - a. Main Circuit Breaker (Flange Handle NEMA 4X): Schneider Model 9422A2
 - b. Main Circuit Breaker (Flange Mechanism): Schneider Model 9422RQ1
 - c. Circuit Breaker (20A, 3P, 600VAC, 65KAIC): Schneider Model HJL36020
 - d. Circuit Breaker (10A, 1P, 120/240V): Cutler Hammer Model QCR1010
 - e. Circuit Breaker (15A, 1P, 12/240V): Cutler Hammer Model QCR1015
 - f. Selector Switch (3 Pos., 30mm, Maintained, Black, 1 NO/1 NC, HOA): Schneider Model 9001SKS43BH13
 - g. Enclosure (24x26x8, 316SS, NEMA 4X w/ Flange Disconnect): Rittal Model WM242608X6
 - h. Enclosure Wall Mounting Bracket (Stainless Steel, for Rittal EA/EX): Rittal Model SZ 2433.000
 - i. DIN Rail (pre-punched, aluminum): Custom Connector Corporation Model C-107-PM
 - j. Fuse (10A, 600V, 13/32" x 1.5", Class CC): Ferraz Shawmut Model ATQR10
 - k. Fuse (20A, 600V, 13/32" x 1.5", Class CC): Ferraz Shawmut Model ATQR20
 - l. Fuse Block (3P, 30A, 600V, Class CC, Indicator): Wohner Model 31-300
 - m. Mushroom Switch (35mm, NC, NEMA 4X): Schneider Model 9001SKR9R20H6
 - n. Pilot Light (PTT, 30MM SK+options, green, plastic fresnel, 120V AC/DC): Schneider Model 9001SKT38LGG31
 - o. Pilot Light (PTT, 30MM SK+options, red, plastic fresnel, 120V AC/DC): Schneider Model 9001SKT38LRR31
 - p. Pilot Light (PTT, 30MM SK+options, white, plastic fresnel, 120V AC/DC): Schneider Model 9001SKT38LWW31
 - q. Pilot Light (PTT, 30MM SK+options, amber, plastic fresnel, 120V AC/DC): Schneider Model 9001SKT38LYA31

- r. Push Button (non-illuminated, 30mm, black, w/o contacts): Schneider Model 9001SKR1B
- s. Contact Block (green, 30mm, 1 NO, w/ screw clamp): Schneider Model 9001KA2
- t. Contact Block (red, 30mm, 1 NC, w/ screw clamp): Schneider Model 9001KA3
- u. Contactor (NEMA): ABB Model AF16-30-10-13
- v. Auxiliary Contact Block (1 NO / 1 NC, for use with AF09-AF96): ABB Model CAL4-11
- w. Mechanical Interlock (for use with AF09-AF38): ABB Model VM4
- x. Motor (Circuit Breaker, NEMA): Schneider Model GV2P20
- y. Auxiliary Contact Block (for GV2 & GV3, 1 NO & 1 NC, side mount): Schneider Model GVAD0110
- z. Relay (10A, 120VAC, 3PDT, 11-Blade, LED): Schneider Model RUMF32F7
- aa. Socket (11-Blade, 3P, 12A, 300V, for RU Series): Schneider Model RUZSF3M
- bb. Current Switch (Adjustable, 0-200A Range): Dwyer Model CCS-131100
- cc. Surge Arrestor (3 Phase, 480V, Delta, 100kA, w/ Alarm Contact Form C): APT Model TE05XCS10A
- dd. Terminal Block (24/8AWG, 50A, 1P, 1000V, 8.2mm): Phoenix Model 3044131 (UT-6)
- ee. Terminal Block (26/10AWG, 30A, 1P, 600V, 6.22mm): Phoenix Model 3044102 (UT-4)
- ff. Terminal Block (End Block, ENS 35N): Phoenix Model 0800886
- gg. End Cover (D-UK 4/10, UK 5&6): Phoenix Model 3003020
- hh. Jumper (3-Pole, UK6): Phoenix Model 0200059
- ii. Terminal Marker (8mm, blank, white sheet): Phoenix Model 0818072 (UC-TM8)
- jj. Terminal Marker (6mm, blank, white sheet): Phoenix Model 0818085 (UC-TM6)
- kk. Transformer (Fingersafe Cover, T250-5000VA, 1 Pair): Schneider Model 9070FSC2
- ll. Transformer (Type T, 2000VA, 240v480-120V): Schneider Model 9070T2000D1

1.06 SYSTEM DESCRIPTION

- A. Macerators provided for upstream shearing and grinding of biosolids / wastewater treatment plant sludge prior to proposed rotary lobe pumps:

1. General Design Conditions

- a. The macerators shall be capable of treating biosolids / wastewater treatment plant sludge flows into the centrifuge and gravity belt thickening units as specified herein:
 - (i) Sludge type: raw sewage sludge (a mixture of approximately 70% primary sludge and 30% secondary sludge)
 - (ii) Solids content: 1.0 – 2.5 % by weight with a potential maximum value of 3.5%
 - (iii) Solids temperature range: 32 – 113°F
 - (iv) Solids pH range: 5 – 9
 - (v) Specific gravity: Consistent with sewage sludge

- b. Location requirements: The macerators specified herein shall be installed in the Thickener Complex per the Drawings.
 - c. Site conditions: The equipment specified herein shall be suitable for the site conditions as specified herein:
 - (i) Ambient temperature range: 32 – 105°F (indoor)
2. Macerator Design Criteria
- a. Type: Macerator with shearing and grinding capabilities.
 - b. Number of Macerators: Two (2) Macerators
 - c. Design Point: 450 gpm
 - d. Maximum Capacity: 1000 gpm with working pressure across unit of 30 psi
 - e. Macerator Speed: 305 rpm
 - f. Duty: Continuous
 - g. Ambient Environment: Indoors
 - h. Suction Size: 8 inches
 - i. Discharge Size: 8 inches
 - j. Maximum headloss across macerator shall not exceed 2.0 psi at all design points.
 - k. Equipment tags:
 - Thickening Centrifuge Macerators
 - HB-TC-MRT-100 Centrifuge No. 1 Macerator
 - HB-TC-MRT-200 Centrifuge No. 2 Macerator
3. Motor Design Criteria
- a. Drive Type: TEFC Motor
 - b. Drive Speed: 1800 rpm
 - c. Motor: 10 HP, 460 volt, 60 hertz, 3 phase with a service factor of 1.15. Motors shall be non-overloading at any performance point without using any of the service factor.
 - d. Motors shall meet all requirements of Section 16150 – NEMA Frame Induction Motors, 600V and Below.
 - e. The drive unit shall be capable of running in forward and reverse.
4. Gear Reducer Criteria
- a. Gear Ratio: 5.74
 - b. Output Speed: 305 rpm
 - c. Output Torque: 4964 lb-in
5. Coupling Criteria
- a. Size: 75
 - b. Material: Cast iron (GJL)
6. Control Criteria
- a. The unit shall be equipped with a control panel. The unit will be monitored by SCADA via the Centrifuge Control Panel.
 - b. The control panel shall allow for start and stop and manual and automatic auto-reverse when a jam is detected.

- c. Refer to Section 16200 – Wires, Conductors and Cables – 600V and Below and Section 17400 – Instrument Panels for Austin Water wiring, conductor and cable requirements.

1.07 SERVICES OF MANUFACTURER'S REPRESENTATIVE

- A. A macerator Manufacturer's factory certified service engineer who has complete knowledge of proper installation, Start-Up, testing, operation and maintenance of the pumping system components as herein specified shall be provided as noted herein and in Section 01730 – Operation and Maintenance Data to test, calibrate and place into service this equipment. Submit qualifications of service engineer for approval.
 - 1. The factory certified service engineer shall advise, consult and instruct the CONTRACTOR on installation procedures and adjustments and inspect the operators during installation as a condition of acceptance of the Work.
 - 2. The factory certified service engineer shall be present during all Start-Up and testing operations to make final adjustments as a condition of acceptance of the Work. Refer to Section 11361 – Centrifuge Thickening Equipment for thickening system Start-Up procedures.
- B. A Macerator Manufacturer's approved representative shall be provided to instruct the OWNER's plant operation and maintenance personnel in the proper operation and maintenance (O&M) of the equipment in accordance with the provisions of Section 01730 – Operation and Maintenance Data and as specified herein.
 - 1. Operating and maintenance manuals shall be furnished to the OWNER as provided in Section 01730 – Operations and Maintenance Data. The manuals shall be prepared specifically for this installation and shall include all required cut sheets, drawings, equipment lists, descriptions, etc. that are required to instruct operating and maintenance personnel unfamiliar with the macerator operation and maintenance. In addition to the requirements of Section 01730 – Operation and Maintenance Data, the manuals shall include the following at a minimum:
 - a. Complete parts list, cross-referenced to exploded view assembly drawings.
 - b. Step-by-step disassembly and reassembly instruction.
 - c. Dimensional drawings for all provided components with their respective weights.
 - 2. OWNER training shall be provided and shall include operational instructions to three (3) separate operational teams over a minimum of three (3) separate time periods. Training shall be given at times convenient to the operational team being trained in light of 12-hour operational shifts and duties while on shift. Accordingly, some operational training will have to be conducted during hours outside a normal Monday through Friday, 7:00 AM to 3:00 PM CST. Operational training shall include the following at a minimum:
 - a. Control and operation of all equipment and appurtenances provided with the macerators.
 - b. Troubleshooting guidance.
 - c. Recognizing normal and abnormal operating conditions.
 - 3. OWNER training shall also include maintenance instructions to one maintenance team. Maintenance training shall be conducted during the hours of 7:00 AM to 3:00

PM EST, Monday through Friday, with the exact schedule being determined in light of on-going maintenance team duties. Maintenance training shall include the following, at a minimum:

- a. Step-by-step assembly and disassembly procedural requirements.
- b. Replacement part identification and ordering procedures.
- c. Lubrication procedures.
- d. Torque and limits switch adjustment.
- e. Recommended routine maintenance procedures.
- f. Trouble-shooting and diagnostic procedures.

- C. Person-hour requirements tabulated below are exclusive of travel time and do not relieve the CONTRACTOR of obligation to provide sufficient services to place all equipment and appurtenances into satisfactory operation.

Services to be Provided by the Factory Representative	Minimum Number of Trips	Minimum Time On-Site Per Trip (Hours)
1. Supervise and assist in the installation of the macerators	2	8
2. Supervise initial adjustment as necessary, instruct in the Start-Up and Acceptance Testing of macerators ^(a)	2	8
3. Train OWNER's Operations and Maintenance Personnel ^(b)	1	16

^(a) Instruction may be given upon completion of Item 1, provided that the installation is successful and the O&M manuals have been submitted to and reviewed by the ENGINEER.

^(b) May be done upon completion of Item 2, provided that the Start-Up and testing is successful.

1.08 SPARE PARTS

- A. All spare parts requirements as specified in related Sections (including Section 11000 – Equipment General Provisions) shall apply to the work described herein.
- B. All working parts of the macerators and motors, such as bearings, wearing rings, etc., shall be standard dimensions built to limit gauges or formed to templates, such that parts will be interchangeable between like units and such that the OWNER may, at any time, obtain replacement and repair parts for those furnished in the original machines.
- C. Each macerator shall be furnished with a complete set of the Manufacturer's suggested spare parts, including but not limited to:
 1. Three (3) replacement cutter blades / rotating blades
 - a. RR6031 Knife 1.8159 RR6000
 - b. RR6230 Gegenschneide for Schiene 30 x 15, 1.8714 RR6000
 2. Three (3) knock-out pins for mounting replacement blades / spacer sleeves for mounting rotating blades
 - a. UH2022 Spacer ring, HPL 200, 8.5mm, 1.0038

3. Provide lubricants (greases and / or oils) necessary to maintain each macerator for the two (2) years of operation.
 - a. 1417999996 Intermediate Oil

1.09 DELIVERY, STORAGE AND HANDLING

- A. All parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment unit installation is completed and the equipment is ready for operation.
- B. CONTRACTOR shall review the contents of the shipment at time of delivery and promptly notify the carrier and Macerator Manufacturer of any discrepancies.
- C. Equipment shall be handled and stored in accordance with the Manufacturer's instructions. None of the components of the equipment shall be dropped and all the components shall be examined before installation. No items shall be installed which are found to be defective and must be repaired to the satisfaction of the ENGINEER.
- D. Factory assembled parts and components shall not be dismantled for shipment or storage unless recommended by the Macerator Manufacturer in writing to the ENGINEER.
- E. The finished surfaces of all exposed flanges shall be protected by wooden or equivalent blank flanges, strongly built and securely bolted.
- F. Finished iron or steel surfaces not factory painted shall be properly protected to prevent rust and corrosion.
- G. No shipment shall be made until approved by the ENGINEER in writing.

PART 2 PRODUCTS

2.01 MACERATOR

- A. General
 1. The in-line macerator shall be capable of conditioning solids suspended in liquid through the use of a minimum of eighteen (18) knives and nine (9) counter blades rotating on a reversible, abrasion resistant metal wearplate.
 2. The macerator shall be capable of both grinding and shearing the solids suspended in liquid.
- B. Macerator Construction
 1. Counter Blades / Knives
 - a. The cutter section of the unit shall have the ability to either be removable with the main body housing remaining in situ OR to open and swing out of the way. Both options shall allow for the inspection and replacement of all wear items and must be accomplished while not disturbing the pipework in any way. The unit shall have a safety switch to automatically lock out the electrical current when the unit is opened.

- b. The cutter blades / knives shall be constructed of Hardox XAR 400.
 - c. The cutter blades / knives shall be connected to the headstock through a simple, re-usable system of knock-out pins. The use of screw or bolt connections to hold the blades / knives to the cutter head will not be accepted.
- 2. Wear Plate
 - a. The construction of the wearplate shall be such that it allows for constant blade support through the entire range of motion.
 - b. The standard wearplate openings will allow for the reduction of solids to equal to or less than 3/4-inch.
- 3. Shafts
 - a. The shafts of the unit shall be constructed from heat treated 4140 alloy steel with a minimum tensile strength of 150,000 psi.
- 4. Seals
 - a. The unit shall be equipped with a mechanical seal suitable for 30 psi operation.
 - b. The mechanical seal shall not be equipped with any springs.
- 5. In-Line Pot / Chamber
 - a. The interior design of the in-line pot / chamber shall be such that it uses a cyclone effect to remove metal and other heavy solids that may cause damage to the cutting blades.
 - b. The pot / chamber shall be equipped with one (1), 4-inch ball valve.
 - c. The pot / chamber shall be equipped with one clean-out flange.
- 6. Vibration
 - a. The macerator shall operate at any point in its operating range without excessive noise and vibration. Vibration at any point in the operating range shall not exceed limits allowed by the Hydraulic Institute.
- 7. Suction and Discharge Connections
 - a. Suction and discharge connections shall be ANSI 150-pound flanges.
- C. Electrical
 - 1. See Section 16150 – NEMA Frame Induction Motors, 600V and Below for electrical requirements.
 - 2. A safety switch will be installed on the unit to automatically lock out the electrical current when the unit is opened.
- D. Instrumentation
 - 1. Refer to Section 17920 – Control Narrative for the macerator control description.
 - 2. Refer to Section 16700 – Common Control Panel Requirements for Equipment
 - 3. Control Panel Requirements
 - a. All controls shall be hard-wired relays. A PLC is not allowed.
 - b. NEMA 4X 316 stainless steel enclosure with three (3) point latching handle.
 - c. Main control power disconnect for incoming power.
 - d. Forward and reverse contactors with motor protection.
 - e. Current sensing switch used for jam condition.
 - f. Hand-Off-Auto selector switch.

- g. Power, Stop and Fault LED and ETM Indicators. Forward and Reverse illuminated pushbuttons.
- h. Emergency Stop pushbutton.
- i. Panel components and cables shall meet the COA standard specifications outlined in Division 16 and Division 17.
- j. Panel control color scheme shall meet COA standards.

2.02 PAINTING

- A. Equipment, frames, baseplates, appurtenances, etc., shall receive surface preparation, prime coating and one finish coating in the factory prior to shipment in accordance with applicable requirements of Section 09900 – Painting. The CONTRACTOR shall apply a second finish coating in the field to all valves and piping, and touchup paint to the equipment. Colors shall be selected by the OWNER during submittal reviews. The CONTRACTOR shall provide a manufacturer's standard factory applied epoxy coating to macerator and motor.
- B. Machined, polished, and non-ferrous surfaces shall be coated with corrosion prevention compound.

PART 3 EXECUTION

3.01 FACTORY TESTING

- A. Hydrostatic Test: The macerators shall be tested to Hydraulic Institute standards.
- B. Vibration Test: Demonstrate the macerator runs smoothly during testing.

3.02 INSTALLATION

- A. All equipment and accessories shall be installed in accordance with the Manufacturer's written recommendations, as approved by the ENGINEER, as shown on the Drawings and in accordance with all OSHA, local, state and federal codes and regulations. Mount systems as indicated.
- B. The CONTRACTOR shall be responsible for installing equipment that the Manufacturer could not ship assembled as an integral part of the system due to shipping restrictions. These items shall be identified on the Manufacturer's approval drawings.
- C. Do not begin fabrication or erection prior to submittal approval.
- D. Factory mount macerator and motor, coupled together, on a common groutable steel base, properly braced to form a rigid support for the entire unit. Factory align the units on the base prior to shipment. Final alignment shall be performed in the field following base grouting and piping connections.

3.03 FIELD INSPECTION, PERFORMANCE TESTING, AND START-UP

- A. Prior to Start-Up, all equipment shall be inspected by the Manufacturer's certified service engineer for proper alignment, quiet operation, proper connection and satisfactory

performance. Provide written certification from the certified service engineer that the equipment is performing and operating as intended and is approved for Start-Up.

- B. Start-Up shall be performed per Section 11361 – Centrifuge Thickening Equipment.
- C. Any component parts which are damaged as a result of Performance Testing, Start-Up or which fail to meet the requirements of these Specifications shall be replaced, reinstalled and re-tested at the CONTRACTOR's expense.

3.04 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 11361

CENTRIFUGE THICKENING EQUIPMENT

PART 1 GENERAL

1.01 SCOPE

- A. The work requires that the Centrifuge Manufacturer accept responsibility for furnishing a complete Thickening System as indicated in the Specifications and on the Drawings but without altering the CONTRACTOR's responsibilities under Contract Documents.
- B. The CONTRACTOR shall perform the demolition of the existing Thickening System as shown on the Drawings. The CONTRACTOR shall furnish labor and materials as required for the storage and installation of the thickening centrifuge units.
- C. The CONTRACTOR will be responsible for equipment unloading and storage of the centrifuge Thickening System per the direction of the Centrifuge Manufacturer. The CONTRACTOR shall install and place in satisfactory operation the two (2) thickening centrifuge units, equipped complete, as shown on the Drawings and as specified herein. All necessary and desirable accessory equipment and auxiliaries, whether specifically mentioned herein or not, shall be furnished and installed as required for an installation incorporating the highest standards for this type of equipment.
- D. The Centrifuge Manufacturer shall provide the specified services of factory-trained field technicians for supervising the installation, debugging and optimization of the system. The Centrifuge Manufacturer shall be responsible for verification of system installation, Start-Up, conducting all acceptance testing, and operation and maintenance training of the OWNER's personnel on the complete operating centrifuge Thickening System.
- E. The Centrifuge Manufacturer shall have responsibility to provide a complete and functional Thickening System that includes the following components in addition to the Centrifuge Thickening Equipment. The Centrifuge Manufacturer shall be responsible to provide all equipment and coordinate all controls so the equipment operates as a complete Thickening System as intended and described in Section 17920 – Control Narrative:
 - 1. Section 11318 – Progressive Cavity Pumps
 - 2. Section 11323 – Rotary Lobe Pumps
 - 3. Section 11330 – Macerators
 - 4. Section 17520 – Instruments
 - 5. Section 17400 – Instrument Panels
 - 6. Other controls and appurtenances needed for a complete and functional system

1.02 RELATED WORK

- A. Drawings and all provisions of the contract documents shall apply to this Section.
- B. Division 1 – General Requirements

- C. Special Provision 410S – Concrete Structures
- D. Section 03600 – Grout
- E. Section 06500 – Fiberglass Reinforced Plastics & Fabrications
- F. Section 09900 – Painting
- G. Division 11 – Equipment
- H. Division 16 – Electrical
- I. Division 17 – Instrumentation

1.03 DEFINITIONS

- A. Thickening System: A Thickening System is defined as a macerator, sludge feed pump, centrifuge and sludge discharge pump arranged in series to achieve sludge thickening.
- B. Solids Capture Rate: Solids capture is defined as the percent of the total solids content in the raw feed solids flow that remain in the thickened end product on a weight basis. For purposes of this specification, the solids capture rate is defined as:

$$SCR = \frac{TS_{\text{discharge}}}{TS_{\text{feed}}} \times \frac{TS_{\text{feed}} - TSS_{\text{centrate}}}{TS_{\text{discharge}} - TSS_{\text{centrate}}} \times 100\%$$

- Where
- SCR = Solids capture rate, % by weight
 - $TS_{\text{discharge}}$ = Total solids in the thickened cake discharge, % by dry weight
 - TS_{feed} = Total solids in the raw feed solids flow, excluding any dilution from the polymer solution flow, % by dry weight
 - TSS_{centrate} = Total suspended solids in the centrate flow, excluding any dilution from the polymer solution, % by weight

- C. Solids Content: Solids Content is to be defined as the percent of total solids in the raw feed solids flow on a weight basis, excluding the polymer solution flow, % by dry weight
- D. Polymer Consumption: Polymer Consumption is to be based on 100% active polymer.
- E. G-volume: G-volume is to be defined as a function of the solids acted on by G-force while inside the cylindrical section of the centrifuge. This value is proportional to the speed of the centrifuge and is calculated thus:

$$G - Volume = K \times W^2 \times D_b \times L \times (D_b^2 - D_d^2)$$

- Where
- K = Constant (4.83×10^{-8})
 - W = Operating Speed, rpm
 - L = Clarification Length of Bowl (Length of Bowl's Cylindrical Section), inches
 - D_d = Cake Discharge Diameter, inches
 - D_b = Bowl Diameter, inches

1.04 SUBMITTALS

- A. Submit to the ENGINEER, in accordance with Section 01300 – Submittals and Section 11000 – Equipment General Provisions, shop drawings and equipment data. All submittal requirements as specified in related Sections shall apply to the work described herein.
- B. Process information including capacity, loading, flow rates and concentrations, polymer requirements (Centrifuge Manufacturer's recommended type, dosage, feed solution concentration), percent solids capture rate, power requirements and discharge percent solids.
- C. Shop drawings specific to the project including but not limited to complete installation and assembly drawings, showing the Centrifuge Manufacturer's dimensions for the thickening centrifuge units furnished herein. Shop drawings shall include the following information as a minimum:
 - 1. Centrifuge Manufacturer and model number of each type of equipment.
 - 2. G-volume calculation and supporting shop drawings for the clarification length of bowl (L), cake discharge diameter (D_d) and bowl diameter (D_b).
 - 3. Centrate and discharge solids chutes (including sample tap, flushing and venting connection locations).
 - 4. Polymer connection locations and routing.
 - 5. Odor Duct System connections, including duct layout and supports.
 - 6. Centrifuge platforms, including material specifications, layout, supports and elevations.
 - 7. Layout and installation drawings of a complete thickening centrifuge unit, including all proposed components with dimensions, foundation details, clearances required, sizes indicated, important details of construction, anchor bolt loadings, total operating weights of the product (sludge, water, equipment, etc., wet and dry), and loadings to supports, drainage piping and other information necessary to install the equipment.
- D. Detailed specifications and data describing the materials of construction, thicknesses, coatings and linings.
- E. List of the CONTRACTOR's responsibilities.
- F. List of the Centrifuge Manufacturer's responsibilities.
- G. Details of Thickening Centrifuge Units, including (but not limited to) the following:
 - 1. Field and installation requirements, including mounting and access requirements and total weight of each component and each complete assembly.
 - 2. Abrasion protection and surface preparation / painting as specified.
 - 3. Centrate drainage/collection system.
 - 4. Drive systems including speed range, drive configuration, speed reducer, motor name plate data, drive controller features, schematics, utility requirements, hydraulic components, valves, piping and control devices.
 - 5. Scroll conveyors including feed distributor and pool settings.
 - 6. Scroll exchange program.

7. Bearings including bearing Manufacturer, housing type, warranty life and certified calculations of AFBMA L-10 bearing life.
 8. Wash system, including washwater supply requirements (flow and pressure).
 9. Inlet feed line.
 10. Required anchor bolts.
 11. Vibration isolators.
 12. Centrifuge Manufacturer recommended polymer input location(s).
 13. Electrical components including enclosures, and machine mounted components.
 14. Differential speed control as specified.
 15. Special shipping, storage and protection, and handling instructions.
- H. Complete information on electric motors for each type of equipment furnished including make and type of motor, brake horsepower at full voltage, guaranteed minimum rated efficiency, speed torque curves, AFBMA L-10 bearing life and all nameplate data.
- I. Complete electrical and instrumentation wiring diagrams and data on controls to be furnished, including, but not limited to the following items:
1. Complete Thickening System interconnection diagrams between power supply, control panels, drive motor, secondary drive motor and all ancillary equipment connected to control system, including terminal number connection points.
 2. Control panel overall dimensions and layout of external and internal mounted components.
 3. Complete electrical schematics with power and control wiring diagrams of field connections with identification of terminations between local panel, junction boxes, equipment items, instrument devices and the like in accordance with the current standards. Schematics shall include all component ratings.
 4. Complete electrical control schematic diagram.
 5. Provide description of control system in both written and schematic form including functions monitored, controlled and alarmed. Include sequence of operation and interface requirements.
 6. Control component itemized information and data.
 7. Electrical one-line diagram.
- J. Elevation and location of emergency stop panel mounted device. Provide details of power distribution and full load current draw of panel. Provide list of all terminations required to receive inputs or transmit inputs from the local panel.
- K. Provide PLC submittal. The submittal shall include PLC database and PLC configuration. The database shall have all PLC/OIU points included with tags, descriptions, addresses, range, and engineering units. Provide an electronic spreadsheet copy to the City's SCADA Programming Engineer. The PLC submitted shall conform to Section 17300 – Programmable Logic Controller (PLC) Requirements.
- L. Provide a complete OIU configuration submittal. The submittal shall include OIU configuration, database, alarm and event configuration, and screens. OIU screens shall be in color.

- M. Centrifuge Manufacturer's recommended type of lubrication recommended for all equipment.
- N. Polymer Testing results and Centrifuge Manufacturer's recommended polymer type and manufacturer.
- O. Complete factory testing requirements and results for each type of equipment specified herein (including test procedures and certifications). A report of the factory test results is required prior to delivery of the equipment to the jobsite.
- P. A list of the Centrifuge Manufacturer's recommended spare parts, special tools and consumable materials (such as lubrication or oil) to be furnished. Supply details of the proposed special tools steel job site box (specified herein). The Centrifuge Manufacturer's warranty agreement and special guarantee in compliance with the Contract Documents, including statement of minimum hours of bowl life warrantied.
- Q. Certifications of the Centrifuge Manufacturer's factory certified engineer or technician.
- R. Centrifuge Manufacturer's Installation Instruction and certificates for proper installation which states that the equipment meets all the design and performance requirements of this Specification.
 - 1. Installation, Start-Up, and test schedule with installation and test procedures shall be furnished prior to installation of the equipment.
 - 2. Owner Training lesson plan.
- S. Certification of Compliance or complete list of all deviations from the Drawings and/or Specifications. This certification must also indicate that the operating personnel have been suitably instructed in the operation and maintenance requirements of each of the components of the Thickening System.
- T. Submit Operation and Maintenance manuals for the entire thickening centrifuge unit, including each component and its interaction with the system, in accordance with Section 01730 – Operation and Maintenance Data and Section 11000 – Equipment General Provisions.

1.05 REFERENCE STANDARDS

- A. Design, manufacture, and installation of the thickening centrifuge herein specified shall be in accordance with, but not limited to published standards of the following as applicable:
 - 1. American Gear Manufacturer's Association (AGMA)
 - 2. American Institute of Steel Construction (AISC)
 - 3. American National Standards Institute (ANSI)
 - 4. American Society of Mechanical Engineers (ASME)
 - 5. American Society for Testing Materials (ASTM)
 - 6. American Welding Society (AWS)
 - 7. Anti-Friction Bearing Manufacturer's Association (AFBMA)
 - 8. Institute of Electrical and Electronics Engineers (IEEE)

9. National Electric Code (NEC)
10. National Electrical Manufacturer's Association (NEMA)
11. Occupational Safety and Health Administration (OSHA)
12. Steel Structures Painting Council (SSPC)
13. Underwriters' Laboratories, Inc. (UL)

1.06 QUALITY ASSURANCE

- A. All components in the thickening centrifuge units shall be supplied by a single Centrifuge Manufacturer. The Centrifuge Manufacturer shall be responsible for assuring a complete and operable Thickening System.
- B. All calculations shall be sealed by a licensed Professional Engineer.
- C. All equipment shall comply with the requirements of Section 11000 – Equipment General Provisions.
- D. Appurtenant equipment shall be new and shall be designed, fabricated and assembled in accordance with the best engineering and shop practices. Individual parts shall be manufactured to standard sizes and gauges. Components of the thickening units shall be designed for the stresses which may occur during fabrication, shipping, erection or maintenance. Materials shall be suitable for service conditions and as described herein.
- E. Thickening Centrifuge Manufacturer shall maintain a complete stock of spare parts commonly needed for the equipment specified. Additional spare parts must be made available within a 48-hour period.
- F. Scroll replacements must be made available within a 48-hours period.
- G. The equipment, sizes, materials and arrangements described herein are based on recommendations by equipment manufacturers and shall be considered maximum or minimum limits of acceptability. Variances to those shown on the Drawings or Specifications shall require the ENGINEER's written approval.
- H. The Centrifuge Manufacturer will construct and supply all equipment specified herein, including the drive units. Systems consisting of components from different Centrifuge Manufacturers will not be acceptable.
- I. The Centrifuge Manufacturer shall submit for approval a certified quality plan covering all aspects of shop fabrication, and if applicable, the field installation of systems to be provided as part of this specification. The quality plan and quality control procedures shall comply at a minimum with the requirements of ISO 9001 or the most current standard as appropriate. Third party certification to ISO 9001 is preferred and if registered accreditation credentials are presented all further responsibility of demonstrating an approved quality plan shall be waived. The CONTRACTOR/Sub-contractor/Centrifuge Manufacturer may propose incorporation of their own non-certified quality control procedures within the quality plan subject to review and ratification by the OWNER and/or ENGINEER. If a non-certified quality plan is approved and used, documented procedures and inspection check sheets covering all work stages

shall be provided, as applicable to the equipment and/or material being provided. The procedures and documentation provided should be based on a recognized quality model, at a minimum.

J. Acceptable Manufacturers:

1. CONTRACTOR and Centrifuge Manufacturer shall match existing equipment installed where possible.
2. Centrifuge: Andritz Model D7LL with TurboJet and Easy Pond System, as manufactured in Arlington, Texas.
3. Bowl Drive Motor (150hp, 460V, 3P, 60Hz, 1800rpm): Baldor Model ECP84406T-4 133131403
4. Back Drive Motor (20hp, 480V, 3P, 60Hz, 1775rpm): Baldor Model ECP82334T-4 133131404
 - a. Fan Connectors (non-metallic, flexible, Neoprene/Buna-N, 3/8"): Proco Series 500 Model Style 540
 - b. Expansion Joints (molded, wide-arch, Neoprene, Chlorobutyl, grey): Proco Series 260 Model 261/NB, 262/NB
5. Control Component (listed for convenience; CONTRACTOR shall match existing centrifuge installation components):
 - a. Vibration Sensor (VK, M12, DIN ISO 10816): ifm Model VKV022
 - b. Socket (M12, 250 AC / 300 DC, 4A): ifm Model EVC006
 - c. Field Cuttable RTD (100 ohm Platinum, 24"): Weed Instrument Model 110-01B-A-4-C-24/NS1/
 - d. Connection Head Code 2 (general purpose aluminum, 1/2" NPT x 3/4" NPT – industry standard): Weed Instrument Model 2A00D1
 - e. PC Programmable RTD Temperature Transmitter: Weed Instrument Model 4500H 4HQT3U-050+0300C
 - f. Inductive Sensor (8mm flush): Pepperl+Fuchs Model NCB8-18GM40-N0-V1
 - g. Mounting Brackets (24 x 24 x 12): nVent Hoffman Model CSD242412SS6
 - h. Mounting Rail (35 x 7.5mm, zinc-plated clear, chromated steel, EN60715): Rockwell Automation Model 199-DR1
 - i. Fuse Holders: Allen-Bradley Model 1492-FB3C30-L
 - j. Time-delay Fuses (LP-CC Clas CC 60Vac/300Vdc, 1/2-30A): Eaton Model LP-CC-20
 - k. Terminal Block: Phoenix Model 3044102, Model 3004362, Model USLKG 5 0441504
 - l. End Cover (D-UT 2.5/10, gray): Phoenix Model 3047028
 - m. End Cover (D-UL 4/10): Phoenix Model 3003020
 - n. End Clamp (E/NS 35 N, gray): Phoenix Model 0800886
 - o. Marker for Terminal Blocks: Phoenix Model 0824589, Model 0824597
 - p. Plug-in Bridge (FBS 20-6, red): Phoenix Model 3030365
 - q. Plug-in Bridge (FBS 10-6, red): Phoenix Model 3030271
 - r. Plug-in Bridge (FBS 10-8, red): Phoenix Model 3030323
 - s. Partition Plate (ATP-UT, gray, 50 x 2 x 48mm): Phoenix Model 3047167

- t. EMC Filter (15A, 3PH): Schneider Model VW3A4422
- u. Schneider Model VW3A4553
- v. Motion Servo Drive (Lexium32, 3P, 204/480V, 1.8kW): Schneider Model LXM32MD18N4
- w. Ethernet TCP/IP Communication Module: Schneider Model VW3A3616
- x. TeSys VLS (body switch disconnect, 3 poles, 23A, on DIN rail): Schneider Model VLS3P032R1
- y. TeSys VLS (rotary handle, holefixing, red, shaft 5mm, 65 x 65mm, defeatable): Schneider Model VLSH2H5RD
- z. Load Center Grounding Bar Assembly: Schneider Model PK9GTA1
- aa. SinCos Hiperface encoder cable (3 x (2 x 0.14mm²) + (2 x 0.34mm²), 15m): Schneider Model VW3M8102R150
- bb. Power Cable (between servomotor BSH and servodrive, 4 x 2.5mm², 15m): Schneider Model VW3M5102R150
- cc. Servo motor (BMH, 3.3Nm, 6000rpm, keyed shaft, with brake): Schneider Model BMH1001P12F2A
- dd. TeSys VLS (shaft extension, 300mm, 5 x 5mm²): Schneider Model VLSS3005
- ee. TeSys VLS (set of 2 terminal covers for 3 unit terminals): Schneider Model VLSC3P1
- ff. Enclosure (free-stand, type 4X, single and dual access, 316L stainless steel): nVent Hoffman Model A904820SSFSDN6 (custom)
- gg. Panels (for free free-stand single and dual access two-door enclosure): nVent Hoffman Model A90P48F1
- hh. Push Buttons – Selector Switches (30.5mm): Allen-Bradley Model 800H-2HRWH2KB6AX
- ii. Contact block: Rockwell Model 800T-XD1M
- jj. Contact block: Rockwell Model 800T-XD2M
- kk. Push Buttons – Emergency Stop Operators (30.5mm): Allen-Bradley Model 800HC-TFRXT6A5S
- ll. Round Beacons: Allen-Bradley Model 855BS-N35BL4
- mm. Vibratone Horns: Federal Signal Model 350-120-30
- nn. Panel Mount Gasket Kit: Federal Signal Model K8435666A
- oo. Large Folding Shelf: nVent Hoffman Model AASHLF1218
- pp. Door Switch Assembly: nVent Hoffman Model ALFSWD
- qq. Supplementary Protector / Miniature Circuit Breaker: Model 1492-SPM1C020, Model 1492-SPM1C030, Model 1492-SPM1C040, Model 1492-SPM1C050, Model 1492-SPM1C080, Model 1492-SPM1C150
- rr. Frequency Converter (1-ch, 24V DC): Rockwell Model 937CU-DIFRQ-DC1
- ss. General Purpose Relays: Allen-Bradley Model 700-HA33A1-4
- tt. Switched Mode Power Supply (240W): Allen-Bradley Model 1606-XLE240EN
- uu. Surge & Filter Protection: Allen-Bradley Model 4983-DC120-20

- vv. Safety Control Relays (60Hz, 120V): Allen-Bradley Model Bulletin 700S-CF620C
- ww. IEC Contactors: Allen-Bradley Model 100-SA20
- xx. General Purpose Relays: Allen-Bradley Model 700-HA33A1-3-4
- yy. General Purpose Relays: Allen-Bradley Model 700-HN205
- zz. Bus Bars: Rockwell Model 1492-A1BB
- aaa. Circuit Breakers Rockwell Model 1489-M1D200
- bbb. APC Smart-UPS SRT (1000VA 120V): Schneider Model SRT1000XLA
- ccc. Dry Contact I/O SmartSlot Card: Schneider Model AP9613
- ddd. Industrial Ethernet 2000 Series Switches: Cisco Model IE-2000-8TC-G-L
- eee. Compact Shielded CAT 6 Patch Panel: DINSpace Model SNAP-CU-12
- fff. HotSwap MBP (1500VA, 120V): Eaton Model EHBPL1500R-PDU1U
- ggg. T32 AC/DC DIN Rail Mount Hour Meter: Model T32F717D
- hhh. LED Light Kit: nVent Hoffman Model LEDD1S35
- iii. EM-DUO (120V AC, 15A, GFI): Phoenix Model 5600462
- jjj. Socket (SD/US, SC, LA, GY): Phoenix Model 2963860
- kkk. Base Element (screw connection, CB1/10-1/10 UT-BE): Phoenix Model 2801305
- lll. Thermomagnetic Device Circuit Breaker (SFB, 2A): Phoenix Model 2800837, Model 2800838
- mmm. Rack M430 (12 slots, panel or plate mounting): Schneider Model BMXXBP1200
- nnn. Analog Output Module M340 (8 outputs): Schneider Model BMXAMO0802
- ooo. 20-way Removable Screw Cap Clamp Terminal Block: Schneider Model BMXFTB2010
- ppp. Non-Isolated Analog Input Module: Schneider Model BMXAMI0800
- qqq. Dry-Running Protection Device TSE: Seepex Model SGRTSE 115V ACB
- rrr. External Mounting (Type 9): Gems Model 164870
- sss. Stainless Steel Magnetically Activated Safety Interlock Switches and Actuators (MA-S20DSC3, 36): Omron Model 44507-0439
- ttt. 700-HA General Purpose Relay: Rockwell Model 700-HA33Z24
- uuu. Thermostats (FLZ 530): Pfannenbergl Model 17121000000
- vvv. PF Series Filterfans: Pfannenbergl Model 11643154055
- www. Exhaust Filters: Pfannenbergl Model 11740004055
- xxx. Interposing/Isolation Relays: Allen-Bradley Model 700-ADL1R
- yyy. Intelligent Temperature Transmitter Model RTT20: Foxboro Model RTT20I
- zzz. PowerFlex 750-Series: Rockwell Model 20G11ND027AA0NNNNN
- aaaa. Molded Case Circuit Breakers: Allen-Bradley Model 140G-J3C3-C60-SD-AA, Model 140G-J6F3-D25, Model 140G-J-TLC13, Model 140G-J-EXT3, Model 140G-J-FMX04
- bbbb. 1489-M Miniature Circuit Breaker: Rockwell Model 1489-M1C010, Model 1489-M1C040, Model 1489-M1C080, Model 1489-M1C200

- cccc. Transformer: Allen-Bradley Model 1497A-A1-M6-0-N, Model 1497A-A13-M6-0-N, Model 1497A-A14-M6-0-N
- dddd. Fan: ADDA Corporation Model AK1781HB
- eeee. TopTherm Fan-and-Filter Unit: Rittal Model 3244.110, Model 3173.100
- ffff. Dual-Element Time-Delay Fuses: Bussmann Model LPJ-2SP, Model LPJ-25SP
- gggg. Fast-Acting Fuses: Bussmann Model KTK-R-1/10
- hhhh. Time Delay / Class CC Fuses (AMP-TRAP 2000): Ferraz Shawmut Model ATQR1, Model ATQR10, Model ATQR15
- iiii. Square Body (DIN 43 653, 690V/700V): Bussmann Model 10-400A
- jjjj. Current Transformers: Rockwell Model 1411-2SFT-301
- kkkk. Transformer (Model 2VT469): Instrument Transformers Model 2VT469-480
- llll. Remote Door Switch: nVent Hoffman Model ALFSWD
- mmmm. LED Light Kit: nVent Hoffman Model LEDA1S35
- nnnn. Heaters: Pentair Model DAH1001A
- oooo. Flanges: Smith-Blair Flange-Lock Restrained FCA model 911 adaptors

- K. The identification of acceptable manufacturers and / or centrifuge models does not exclude the manufacturer from compliance with the requirements stated herein.

1.07 SYSTEM DESCRIPTIONS

A. General Design Conditions:

1. The centrifuges shall efficiently thicken the raw wastewater sludge collected from the equalization tank as specified herein:
 - a. Solids type: raw sewage sludge (approximately 70% primary sludge and 30% waste activated sludge by volume). Raw sludge is sent from two different wastewater treatment plants in Austin (Walnut Creek and South Austin Regional) and may contain lime or magnesium hydroxide precipitates. Volatile Solids range from 3,000 mg/L to 14,200 mg/L.
 - b. Solids content: normal range of 1.0-2.5% dry solids by weight with a potential maximum value of 3.5%
 - c. Solids loading (individual centrifuge): 54,000 to 252,000 pounds/day
 - d. The centrifuge must be designed, fabricated and assembled in accordance with the best engineering and shop practices such that the unit shall generate at least 3000 G's of force at the bowl wall.
 - e. Minimum G-Volume of 568,474 G-Gallons and 3000 G's at a bowl speed of 2,700 rpm for each unit. See Definition section for G-Volume calculation.
 - f. Maximum bowl operating speed of 2,850 rpm.
2. Performance requirements: Each Thickening Centrifuge unit specified herein shall provide the performances as specified herein:
 - a. Solids and Hydraulic Loading Requirements
 - (i) Design Feed Rate: 450 gpm
 - (ii) Thickened Solids Requirements:

- (a) Design: 6% dry solids by weight
 - (b) Minimum: 5.5% dry solids by weight
 - (c) Maximum: 6.5% dry solids by weight
 - b. Design solids capture rate equal to a minimum 95% of feed total solids by dry weight at design feed rate and normal dry solids range.
 - c. Polymer consumption equal to a maximum of 6 active pounds per ton thickened sludge at design feed rate and normal dry solids range.
 - d. Operating schedule at design loading shall be 7 days per week and 24 hours per day.
 - e. The centrifuge units shall be completely enclosed so as to prevent odorous air from escaping the units.
- B. Site Conditions and Size Requirements:
 - 1. The equipment specified herein shall be suitable for the site conditions and size requirements as specified herein:
 - a. Ambient temperature range: 40–104°F (indoors without air conditioning)
 - b. Ambient humidity range: 10% – 90%
 - c. Maximum overall length: 230 inches
 - d. Maximum overall width: 72 inches
 - e. Maximum overall height: 72 inches
 - f. Maximum dry static gross weight: 30,000 pounds
- C. Equipment Tag Numbers
 - 1. Equipment tag names included herein are as follows:
 - a. Thickening Centrifuge No. 1 HB-TC-CE-100
 - b. Thickening Centrifuge No. 2 HB-TC-CE-200
- D. Power Supply Requirement:
 - 1. Main drive: 150 HP per machine
 - 2. Secondary drive: 20 HP per machine

1.08 SERVICES OF CENTRIFUGE MANUFACTURER

- A. A factory-trained qualified service technician shall be provided to instruct the OWNER's plant operation and maintenance personnel in the proper operation and maintenance (O&M) of the equipment in accordance with the provisions of Section 01730 – Operation and Maintenance Data and as specified herein.
 - 1. Operating and maintenance manuals shall be furnished to the OWNER as provided in Section 01730 – Operation and Maintenance Data and Section 11000 – Equipment General Provisions. The manuals shall be prepared specifically for this installation and shall include all required cut sheets, drawings, equipment lists, descriptions, etc. that are required to instruct operating and maintenance personnel unfamiliar with the centrifuge thickener mechanisms' operation and maintenance. In addition to the requirements of Section 01730 – Operation and Maintenance Data and Section 11000 – Equipment General Provisions, the manuals shall include the following at a minimum:

- a. Complete parts list, cross-referenced to exploded view assembly drawings.
 - b. Step-by-step disassembly and reassembly instruction including tolerances and torque requirements.
 - c. Dimensional drawings for all provided components with their respective weights.
 2. Owner Training shall be provided and shall include operational instructions to two (2) separate operational teams over a minimum of twenty-four (24) hours on site.
 - a. The Centrifuge Manufacturer shall submit an Owner Training course outline plan, 3 months before training starts, with proposed class material and class schedule to the OWNER for approval. Training will begin only if the class material and class schedule have been reviewed and approved by the OWNER.
 - b. Training shall be given at times convenient to the operational team being trained in light of 12-hour operational shifts and duties while on shift. Accordingly, some operational training will have to be conducted during hours outside a normal Monday through Friday, 7:00 am to 3:00 pm, work day. Owner Training shall include the following at a minimum:
 - (i) Startup procedures.
 - (ii) Shutdown procedures.
 - (iii) Selection of proper polymer types and dosages.
 - (iv) Control and operation of all equipment and appurtenances of the Centrifuge Thickening Unit, including feed and discharge pumps.
 - (v) Operating adjustments for performance optimization.
 - (vi) Troubleshooting guidance.
 - (vii) Recognizing normal and abnormal operating conditions.
 - (viii) Preventative maintenance, including all maintenance procedures.
 - (ix) Emergency procedures.
 - (x) Record keeping (verify process with OWNER).
 - (xi) All mechanical unit functions and descriptions.
 3. Owner Training shall also include hands-on maintenance instructions to one maintenance team. Maintenance training shall be conducted during the hours of 9:00 am to 3:00 pm, Monday through Friday, with exact schedule being determined in light of on-going maintenance team duties. Maintenance training shall include the following, at a minimum:
 - a. Step-by-step assembly and disassembly procedural requirements.
 - b. Replacement part identification and ordering procedures.
 - c. Lubrication procedures.
 - d. Torque and limits switch adjustment.
 - e. Recommended routine maintenance procedures.
 - f. Trouble-shooting and diagnostic procedures.
 - g. Fuse and pilot lamp replacement.
- B. The Centrifuge Manufacturer's factory certified service technician who has complete knowledge of proper installation, Start-Up, testing, operation and maintenance of the Thickening System components as herein specified shall be provided as noted herein

and in Section 01730 – Operations and Maintenance Data to test, calibrate and place into service the equipment. Submit qualifications of service technician for approval.

1. The factory certified service technician shall advise, consult and instruct the CONTRACTOR on installation procedures and adjustments and inspect the operators during installation as a condition of acceptance of the work.
2. The factory certified service technician shall be present during all Start-Up and testing operations to make final adjustments as a condition of acceptance of the work.

- C. Person-hour requirements tabulated below are exclusive of travel time and do not relieve the CONTRACTOR of obligation to provide sufficient services to place all equipment and appurtenances into satisfactory operation.

Services to be Provided by the Factory Representative	Minimum Number of Trips	Minimum Time On-site Per Trip (Hours)
1. Supervise and assist in the installation of the thickening centrifuges	2	24
2. Inspect and completion of Centrifuge Manufacturer's Certificate of Proper Installation in functional and acceptance testing ^(a)	2	8
3. Supervise and assist in Start-Up and initial adjustment as necessary ^(b)	2	40
4. Supervise and assist in functional and acceptance testing ^(c)	2	24
5. Owner Training – Instruct OWNER and ENGINEER in proper startup and O&M ^(d)	1	24
6. Supervise and assist in Thickening System optimization ^(e)	2	16

^(a) May be done upon completion of Item 1, if acceptable to the ENGINEER.

^(b) Instruction may be given upon completion of Item 2, provided that the test is successful and the O&M manuals have been submitted to and reviewed by the ENGINEER.

^(c) May be done upon completion of Item 2, if acceptable to the ENGINEER.

^(d) May be done upon completion of Items 2 and 3, if acceptable to the ENGINEER.

^(e) Instruction may be given upon completion of Item 4, provided that the test is successful and the O&M manuals have been submitted to and reviewed by the ENGINEER.

1.09 SPARE PARTS AND SPECIAL TOOLS

- A. All spare parts, special tools, supplies and lubricant requirements as specified in related Sections shall apply to the work described herein.
- B. Provide the OWNER a list of all spare and replacement parts with individual prices and locations where available. Prices shall remain in effect for a period of not less than one (1) year after final acceptance.

- C. Spare parts shall be protected from damage, moisture and dirt accumulation. The spare parts shall, if possible, be enclosed within an airtight membrane. Spare parts supplied in matched sets, such as drive belts, shall be wrapped, bound or labeled to indicate a set.
- D. Provide all special tools required for normal maintenance. Special tools shall be packaged airtight and shall be protected from damage, moisture and dirt accumulation. The CONTRACTOR shall provide a minimum 24" x 60" top-opening, lockable, heavy-duty steel job site box (Jobox or equivalent) to house the centrifuge thickening unit special tools (including bowl lifting device(s) and scroll removal/lifting device(s)), spare parts, and consumable materials, including the items provided under the 2018 Hornsby Bend Biosolids Management Plant Thickener Complex Rehabilitation project. The size of the steel job site box shall be large enough to include all items provided. The box shall be heavily constructed and designed as a permanent storage enclosure for the items listed. Tools, spare parts, consumable materials shall be clearly and indelibly marked on the exterior to indicate equipment for which tools are intended. At minimum, the Centrifuge Manufacturer shall furnish the following special tools:

<i>Item</i>	<i>Quantity</i>
1. Universal Tools (including any special wrenches, pliers, screw drives, plastic hammers, etc.)	(1) Set
2. Pin Extractor	(2)
3. Scroll Thrust Bearing Extractor	(2)
4. Greasing Set	(1)
5. Wrenches	(2) Set
6. Threaded Rods	(2) Set
7. Threaded Spindles and Plates	(2) Set
8. Lubricator Extension with Clamps	(1)
9. Needle Bearing Puller	(2)
10. Wrench for Lubricating Nipple	(1)
11. Lifting Straps and Shackles for Bowl Cover	(2) Set
12. T-handle wrench	(1)

- E. Spare Parts: At minimum, the Centrifuge Manufacturer shall furnish the following spare parts:

<i>Item</i>	<i>Quantity</i>
1. Main Drive Bearings	(2) Sets
2. Conveyor Bearings and Seals for Centrifuge	(2) Sets
3. Matched Drive V-Belts for Centrifuge	(2) Sets
4. Seals and O-Rings for Centrifuge	(2) Sets
5. Temperature and Vibration Sensors	(2) Sets
6. Each type printed circuit board for Main Drive	(1) Each
7. Power Diodes for Main Drive	(2)

8.	Power Transistors for Main Drive	(2) Pair
9.	50% Main Drive replacement fuses, all types & sizes	

- F. Consumable Materials: At minimum, the Centrifuge Manufacturer shall furnish the following lubricant, grease and consumable materials:

<i>Item</i>	<i>Quantity</i>
1. All lubricants	(2) 1 Year's Supply (20 gallons minimum), including Initial Oil Change
2. Oil Filters, if required	(2) 1 Year's Supply

1.10 DELIVERY, STORAGE AND HANDLING

- A. Equipment provided herein shall be handled and stored in accordance with the manufacturer's recommendations, and as specified in Section 01600 – Materials and Equipment and Section 11000 – Equipment General Provisions. None of the components of the equipment shall be dropped and all the components shall be examined before installation. No items shall be installed which are found to be defective, and must be repaired to the satisfaction of the OWNER and ENGINEER prior to installation.
- B. All equipment and parts shall be properly maintained and protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment unit installation is completed and the equipment is ready for operation.
1. The centrifuge drain line, centrifuge discharge access trench and centrifuge supports shall be installed prior to the shipment of the centrifuge units.
 2. The centrifuge units shall not under any circumstance be stored outdoors.
- C. Factory assembled parts and components shall not be dismantled for shipment or storage unless recommended by the Centrifuge Manufacturer in writing to the ENGINEER.
- D. Spare parts shall be packaged in containers, labeled clearly with part number, designating contents and pieces of equipment. Spare parts shall be delivered at the same time as pertinent equipment.
- E. The finished surfaces of all exposed flanges shall be protected by wooden or equivalent blank flanges, strongly built and securely bolted.
- F. Finished iron or steel surfaces not factory painted shall be properly protected to prevent rust and corrosion.
- G. No shipment shall be made until approved by the ENGINEER in writing through the submittal process.

1.11 MANUFACTURER'S WARRANTY

- A. The Centrifuge Manufacturer shall warrant that centrifuges shall be free from defective material and workmanship for a period of three (3) years from the date of written

OWNER acceptance. The warranty shall be provided in writing starting from the date of acceptance by the OWNER.

- B. Before the warranty period will begin, equipment must operate as intended for thirty (30) days without failure, maintenance or operator intervention unless it is required as part of the normal function of the equipment. During this 30-day period, the equipment shall perform as stipulated in 1.07. The warranty period will not officially begin until the Centrifuge Manufacturer provides the following Certification and the OWNER subsequently provides a written acceptance of the certification and establishes the warranty start date.
- C. Centrifuge Manufacturer's Certification: Provide a letter of certification addressed to the OWNER and signed by an authorized representative of the Centrifuge Manufacturer. The letter shall state the following:
 - 1. The centrifuge will efficiently and thoroughly perform the required functions in accordance with the Contract Documents.
 - 2. The roles and responsibilities of the Centrifuge Manufacturer and CONTRACTOR for the coordination of equipment, including but not limited to, including but not limited to motors, variable speed drives, controls, and services required for proper installation and operation of the completely assembled and installed unit.
 - 3. The equipment has been installed in accordance with the Centrifuge Manufacturer's requirements, and is in proper adjustment and operating condition, has been operating for a minimum of thirty (30) days without failure (as specified above), the Centrifuge Manufacturer is prepared to warrant the equipment to perform in full compliance with these specifications and the equipment is ready to be turned over to the OWNER for operation.
 - 4. The Centrifuge Manufacturer has inspected the installation and verified training of the OWNER's operations and maintenance personnel upon completion of the Thickening System installation.

PART 2 PRODUCTS

2.01 GENERAL PERFORMANCE REQUIREMENTS

- A. All equipment including controls specified herein shall be specifically designed for the separation of solids from raw sewage sludge (approximately 70% primary sludge and 30% secondary sludge) and the environment encountered in this installation. The environment will be moist and corrosive. The sludge may contain abrasive materials. These and other conditions generally characteristic of wastewater treatment plant sludge are not considered abusive or abnormal with respect to equipment warranty provisions.
- B. Equipment shall be designed and capable of either continuous or intermittent operation. This specification covers certain required features of the equipment, but does not purport to cover all details entering into its design.
- C. All equipment specified herein shall be furnished by the Centrifuge Manufacturer. This does not require that all equipment be manufactured by a single manufacturer, but does

require that the Centrifuge Manufacturer shall be responsible for the satisfactory operation of the Thickening System.

- D. The thickening centrifuge shall be completely factory assembled and tested with control panel drives and motors as appropriate for the industry standards prior to shipment to the jobsite. PLC shall be programmed and factory tested with the solids Thickening System components.
- E. The equipment, sizes, materials and arrangements described herein are based on recommendations by equipment manufacturers and shall be considered minimum limits of acceptability. The Centrifuge Manufacturer shall be responsible for design, arrangement and performance of all equipment supplied herein. Arrangements other than those shown on the Drawings shall be subject to the ENGINEER's approval and shall be at no additional cost to the OWNER.

2.02 CENTRIFUGE

A. General

1. The thickening centrifuge shall consist of a horizontal solid bowl, with scroll conveyor utilizing a speed inducer or gear reducer for changing the differential speed between the rotating bowl and scroll conveyor. Additional components included in this specification that are to be independently mounted include the control panels, variable frequency drives and related electrical components. System shall include, as a minimum, all controls and instrumentation as specified herein and / or presented on the Drawings. Materials and general design of the centrifuge systems shall be the Centrifuge Manufacturer's standard, except as specified herein.
2. The centrifuge shall be dynamically balanced prior to shipment.
3. All wetted parts of the centrifuge rotating assembly shall be at a minimum 316 stainless steel except for the "O" rings, seals and abrasion-resistant material. "O" rings shall be Nitrile rubber; lip-type seals shall be Nitrile rubber.
4. All equipment, supports, anchors and fasteners shall be of adequate strength to withstand loads associated with starting, turbulence, thrusts from liquid movement, thermal expansion and contraction and other loads encountered under normal operating conditions.
5. There shall be no rigid connections at the feed tube, vents, solids discharge, liquid discharge or other components whatsoever to the machine, thus preventing transmission of vibration to structure support, piping and appurtenant equipment. No exterior loads are to be transferred to any of the equipment.
6. No dissimilar metals shall be in direct contact unless properly insulated with a 2 mm thick continuous neoprene gasket.

B. Bowl

1. The bowl shall be centrifugally cast from duplex stainless steel with a minimum tensile strength of 100,000 psi. All centrifugal casts and welded joints shall be examined for cracks, porosity or other defects by means of a liquid dye penetrate test. Bowl inspection reports shall be supplied prior to final acceptance.

2. The pond depth in the centrifuge bowl shall be adjustable through the use of 316 stainless steel sliding weir plates at end of the bowl where liquid is discharged. Cake solids shall be discharged opposite from the liquid discharge.
3. The front and rear bowl hubs shall be centrifugally cast with duplex stainless steel.
4. The bowl shall be manufactured with longitudinal ribs that shall prevent circumferential slippage of the sedimented solids and provide for the formation of a protective solids layer.
5. Solids discharge port(s) shall be protected from corrosion and abrasion per the Centrifuge Manufacturer.
6. The bowl shall be dynamically, independently balanced to allow for exchange of a replacement bowl without need for balancing of the assembled rotating assembly.
7. The centrifuge bowl cover shall be constructed of 316 stainless steel.

C. Scroll Conveyor

1. The centrifuge shall include a 316 stainless steel horizontal cylindrical scroll conveyor.
2. The scroll conveyor shall be supported on oil lubricated anti-friction ball or roller bearings sealed from process contamination.
3. The scroll conveyor shall be independently balanced at full operational speeds such that a scroll conveyor can be interchanged with another from the same model centrifuge.
4. Scroll conveyor shall be designed such that the feed is evenly discharged into the bowl and creating minimum disturbance to the pool for maximum settling of fine particles. The feed chamber wall assemblies shall be protected from abrasion.
5. The edge and face of the conveyor flights shall be protected against abrasion with tungsten carbide inserts tiles. Tile hardness shall meet or exceed 2500 Vickers hardness and pass the requirements of ASTM G-65 testing procedures. A 15,000 hour wear guarantee shall be provided for the wear insert / tile assemblies. In lieu of the 15,000 hour wear guarantee, a spare replacement scroll may be provided.
6. Tile wear shall be monitored by means of visual inspection. Measurable wear to the outer tile edge tips and face shall indicate service schedules. Tile replacement shall be capable of being made in the field without creating unbalanced conditions by removal of the old assembly and welding a new assembly in place.
7. The centrifuge conveyor shall be removable without the displacement of the main drive or secondary drive from the frame thus allowing for ease of inspection.
8. In order to minimize downtime, the manufacturer shall offer a scroll exchange program. The scroll exchange program shall be established where an exchange scroll shall be shipped to the plan site for installation into the centrifuge. The original scroll shall be subsequently shipped back to the repair facility for rework and be placed into the exchange program.

D. Casing Assembly

1. The rotating assembly and bearings of the centrifuge will rest on a carbon steel epoxy-coated frame and 316 stainless steel casing assembly, specifically designed for rigidity and noise reduction.

2. The casing assembly shall be manufactured to contain and direct the solids and liquid (centrate) discharge from the centrifuge and act as a protective guard and to provide a complete enclosure. The bottom of the casing assembly shall be fitted with a flexible splashguard for cake discharge. Both the upper and lower parts of the casing assembly shall be constructed with 316 stainless steel.
3. To limit splashing and air leakage, the casing assembly shall be provided with seals where the bowl hubs intersect the casing assembly and gasket on the machine flanges where the upper and lower parts of the casing assembly join.
4. Lifting hooks shall be provided for lifting the casing assembly.

E. Frame

1. The frame shall support drive motors, rotating assemble, bearings and casing as a single unit. Vibration isolators for the main drive motor and differential speed system motor shall be supplied. A conduit box for all centrifuge mounted switches, except those specifically related to the main drive motor, shall be mounted on the base.
2. The frame shall be manufactured entirely from epoxy- or powder-coated carbon steel, specifically designed for rigidity and noise reduction.

F. Centrifuge Base

1. The centrifuge shall be supported on a fabricated carbon steel base mounted on vibration isolators.
2. The vibration isolators shall be selected and provided by the manufacturer for the service required to isolate the centrifuge unit from the support structure. Isolators shall be specifically sized depending on bowl speed and service conditions so that they have a minimum dampening effect of 98% of all vibration loads in all directions. Isolators shall be designed for seismic and axial loading.
3. Machined surfaces shall be provided at all points where support loads are transferred to the base.
4. Lifting holes, hooks or bars in the base shall be provided as required for lifting of the base by overhead crane.

G. Centrifuge Assembly Bearings

1. All bearings shall have a minimum AFBMA L-10 lifetime rating of 100,000 hours at design operating speeds at 24 hours per day service. They shall be conservatively designed to withstand all stresses of the service specified.
2. The centrifuge shall be designed such that the rotating assembly is supported by two (2) main pillow block bearings. Each main bearing shall be lubricated ball or cylindrical roller type bearing. Refer to Oil Lubrication System section below for lubrication requirements.
 - a. The main bearings shall be equipped with RTD type temperature sensors which monitor the temperature of the bearing race directly. The sensors shall be platinum ohm resistance type PT100.
3. Bearings for the scroll shall be permanently grease lubricated OR oil filled.
4. Bearings for the motors shall be grease lubricated, ball or roller anti-friction type of standard manufacture.

H. Oil Lubrication System

1. Each centrifuge shall be supplied with an oil lubrication unit for the main bearings. The lubrication unit shall be mounted on the centrifuge directly or as shown on the Drawings.
2. The oil lubrication unit shall provide a controlled flow of oil to each main bearing.
3. The oil lubrication unit shall be interlocked with the centrifuge control panel so the oil pump must be operational before the centrifuge can be started.
4. Oil temperature switches shall be provided in the oil return lines or the pillow block bearings to stop the centrifuge on high oil temperature, if forced oil lubrication is provided.
5. It shall be the responsibility of the Centrifuge Manufacturer to provide all information necessary for the CONTRACTOR to connect each oil lubrication system to its respective centrifuge. The lubrication system shall be powered and controlled by the centrifuge power panel and control panel.

I. Vibration Monitoring System

1. The centrifuge shall be equipped with a vibration monitoring system consisting of a minimum of two (2) vibration sensors, digital display, 4-20 mA outputs, alert alarm and danger alarms.
 - a. Upon reaching an alert (stage 1) alarm, the control system will issue a warning alarm at the panel. Upon reaching a danger alarm (stage 2), the control system will shut down the centrifuge in a controlled shut down sequence.

J. Anchor Bolts

1. Anchor bolts shall be sized and recommended by the Centrifuge Manufacturer, and shall be supplied by the CONTRACTOR. Anchor bolts shall be of 316 stainless steel and comply with the requirements of Section 05051 – Anchor Bolts and Section 11000 – Equipment General Provisions.

K. Fasteners

1. All fasteners supplied with the centrifuge unit shall be corrosion-resistant and material shall be 316 stainless steel.

L. Chutes

1. The chutes to direct the flow of solids and centrate (liquid) discharge out of the centrifuge shall be designed and furnished by the Centrifuge. Chutes shall be constructed of 316 stainless steel and supported independently.
2. Centrate Discharge Chute
 - a. The centrate discharge chute shall be fabricated of 316 stainless steel with the top flange matching the rectangular flange of the centrifuge liquid discharge connection and the bottom flange matching the diameter of the drain line as shown on the Drawings. A flexible connection shall be included between the bottom flange of the chute and the drain line. Refer to the Drawings.
3. Solids Discharge Chute
 - a. The solids chute shall be 316 stainless steel and rectangular with a top flange matching the flange of the centrifuge flexible solids discharge connection. The

chute connect the centrifuge solids discharge to the proposed progressive cavity pump. Refer to the Drawings.

- b. The CONTRACTOR shall field route non-potable water to the flushing connection on the chute.
- c. Refer to the Drawings.
- d. Provide a level transmitter to measure the level of sludge in the chute. The level transmitter shall be an ultrasonic level meter and shall be Siemens Echomax XRS-5 Ultrasonic Transducer.
- e. Provide a level switch for level high alarm and Thickening System control. The level switch shall be Gems Level Switch LS-7 Series, Type 9 External Mounting, SPST 20VA. The level switch shall be used to shut down the Thickening System and polymer system when chute high level condition occurs.

M. Centrifuge Access Platforms

1. The Manufacturer shall provide FRP access platforms, stairs, ladders and gates as shown on the Drawings.
2. The Manufacturer shall provide stainless steel handrails as shown on the Drawings.
3. The Manufacturer shall ensure access platforms allow adequate access to all necessary points on the centrifuge. The platforms shall match existing platform configuration for existing centrifuges wherever possible, unless otherwise noted.
4. Refer to Section 06500 – Fiberglass Reinforced Plastics & Fabrications for additional information and requirements.

N. Main Drive System

1. The main drive system shall have an electric main motor and a belt drive system. The belt drive system shall consist of multiple V-belts to provide full load capacity and to withstand the full starting torque of the system.
2. The main drive system shall include a variable frequency drive (VFD) for control and inrush amperage minimization.
3. The main drive system shall have a 316 stainless steel nameplate that contains the Manufacturer's name, model, serial number, size, characteristics, date of Manufacture and appropriate data describing the motor performance ratings.
4. The design, construction, testing and performance of the main drive motor shall conform to the requirements of the latest NEMA, IEE and ANSI standards. The motor nameplate horsepower rating shall be equal to, or greater than, the maximum brake horsepower of the drive system at its maximum hydraulic flow rate.
5. Refer to Paragraph 1.06.J for motor requirements.
6. The main motor bearings shall be conservatively designed to withstand all stresses specified. The main motor bearing life shall be 100,000 hours as defined by AFBMA L-10 Standards.
7. The main motor rotor and stator shall be corrosion resistant. The main motor conduit box shall be gasketed.
8. The maximum temperature rating shall be 104 degrees Fahrenheit.
9. With the main motor at ambient temperature, it shall be capable of making two (2) complete starts in succession with coasting to reset between starts. The main motor

shall also be capable of at least one (1) restart within ten (10) minutes after any shutdown.

10. The main drive system must be designed to offer cleaning capabilities while the centrifuge bowl is at a standstill. Maximum torque and maximum differential speeds shall be available with the bowl at a standstill.
11. The main motor shall be rated by the motor manufacturer as having a noise level not exceeding 85 dBA (sound pressure) when measured at three (3) feet from the motor in any direction with all inlet and outlet openings closed.
12. The main motor shall be equipped with a thermal protection system to protect the motor from temperatures damaging the stator windings resulting from motor overload, frequent starting, locked-rotor current and a variable frequency inverter.
13. All drive belts and pulley guards shall be independent of the main centrifuge for easy removal. V-belts and sheaves shall be of the best commercial grade and shall conform to all applicable standards.
14. Sheaves shall be machined from the finest quality ductile iron. Sheaves shall be statically balanced. Finish bored sheaves shall be complete with 316 stainless steel key seat and set screws.
15. The drive belts and sheaves shall be covered with a 316 stainless steel protective guard independent of the main centrifuge cover for easy removal.
16. The Main Drive shall be provided with the following spare parts. Spare parts shall be boxed or packaged for long term storage. Identify each item with the Manufacturer's name, description and part number on the exterior of the package:
 - a. One (1) of each type printed circuit board
 - b. Two (2) power diodes
 - c. One (1) pair power transistors
 - d. 50% replacement fuses, all types and sizes

O. Differential Speed System

1. Each centrifuge shall be furnished with a differential speed system to control the differential speed between the scroll conveyor and the centrifuge bowl. Each system shall be furnished with all the required instrumentation and electrical controls to meet the operating requirements of this specification.
2. Scroll Drive System Motor
 - a. In the automatic mode, scroll drive speed is varied to maintain constant torque, thereby compensating for varying feed characteristics. The scroll drive system shall utilize an AC inverter and VFD arrangement.
 - b. Refer to Paragraph 1.06.J for motor requirements.
 - c. The centrifuge shall be equipped with a gear reducer unit to control the differential speed between the centrifuge bowl and scroll conveyor. The gear reducer unit shall have a 316 stainless steel safety guard / cover.
 - (i) The gear reducer shall have a torque capacity to meet the expected service conditions and shall be capable of withstanding a 500 percent momentary overload and 150 percent intermittent overload (minimum 66,000 inch pounds).

- (ii) The gear reducer shall meet the requirements of AGMA Class 10 and 11 requirements and be oil lubricated. Lubricating oil shall be self-contained and shall be high performance gear oil.
 - (iii) The gear reducer shall be independently balanced from the centrifuge and interchangeable. Each gear unit shall have a fail-safe overload device to absorb all loading over 110 percent (110%) of the continuous rating of the gearbox. The continuous duty rating of the gear box shall be a minimum of 44,000 inch pounds. A thermal overload protection device in the drive motor shall not be considered as providing for sufficient protection for the gear unit.
 - (iv) The Centrifuge Manufacturer shall select the reduction gear ratio as required for the solids to be handled and to be consistent with satisfactory operation.
 - (v) The units shall be provided with seals of Nitrile-Butadiene-Rubber (NBR 3760). The power transmitting elements shall be made of bearing steel, hardened by either nitriding or carburizing.
3. In case of a high torque shutdown, the differential speed system shall not trip but maintain full torque for the entire shutdown so that the machine clears itself of sludge while under reduced G-force, so it is clean when it comes to a complete stop.
 4. The differential speed system shall be designed such that if needed, it can be replaced without removing and dismantling the rotor.
 5. After power failure, with the machine fully loaded with solids, the differential speeds system must be capable of maintaining differential speed without accelerating the bowl.
 6. The differential speed motor shall have a 316 stainless steel nameplate that contains the Manufacturer's name, model, serial number, size, characteristics, date of Manufacture and appropriate data describing the motor performance ratings.
 7. The Differential Speed Drive shall be provided with the following spare parts. Spare parts shall be boxed or packaged for long term storage. Identify each item with the Manufacturer's name, description and part number on the exterior of the package:
 - a. One (1) of each type printed circuit board
 - b. Two (2) power diodes
 - c. One (1) pair power transistors
 - d. 50% replacement fuses, all types and sizes

2.03 ELECTRICAL

- A. Refer to Division 16 – Electrical for all electrical requirements.
- B. Emergency Stop
 1. An Emergency Stop (E-stop) button shall be provided at a location adjacent to each centrifuge. The button shall be oriented for easy access according to the site requirements. The E-stop button shall be installed in a NEMA 4X 316 stainless steel enclosure.
- C. Centrifuge Electrical Panel

1. The Centrifuge Manufacturer shall provide and the CONTRACTOR shall install an industrial grade Electrical Panel per centrifuge. This panel will provide electrical power supply for the centrifuges and all ancillary equipment specified by the Centrifuge Manufacturer and required herein. The panel shall be installed as shown on the Drawings and specified herein.
 2. The panel shall be constructed of NEMA 4X 316 stainless steel enclosure for housing the VFDs for the centrifuge. The panel shall be free standing single or double door enclosure with through door-operated main disconnect that can be locked in the "off" position. Enclosure shall be UL listed. The panel shall meet the requirements of Division 16 – Electrical.
 3. VFDs for motors larger than 50 HP must be 18-pulse VFD to mitigate harmonic distortion.
 4. Refer to Section 16200 – Wires, Conductors and Cables – 600V and Below for Austin Water wire, conductor and cable requirements.
 5. The panel shall have a main circuit breaker for incoming power disconnection and one (1) circuit breaker for each individual solids thickening equipment power feed. All circuit breakers shall be properly sized to meet the equipment load requirements.
 6. The panel shall be supplied with lightning and surge protection units as specified under Section 16700 – Common Control Panel Requirements for Equipment.
 7. The panel shall include an installed power quality monitoring unit at the main incoming power circuit. The power quality monitoring unit shall be completed configured and fully functional. The power quality monitoring unit shall be GE PQM II. Provide GE Modbus to Modbus TCP gateway and installed inside the Centrifuge Control Panel. The gateway will connect to the Centrifuge Control Panel switch via Cat6. Power quality information for the Thickening System, including Voltage, Current, Frequency and Power Factor, shall be programmed and displayed on the OIU graphic screen.
 8. The panel shall include transformers to provide 120Vac control power for the Control Panel and power for equipment, instruments, lighting, power outlet and other local 120Vac single phase equipment. A minimum of 20% spare breakers shall be included in the low voltage power panel.
 9. It shall be noted that the raw sludge feed pumps and thickened sludge discharge pumps will be powered from a separate MCC.
- D. The centrifuge shall be supplied with the following NEMA 4X rated components: Stainless steel terminal box, bearing temperature probes for the rotating assembly support bearings and vibration sensor. All components shall be wired complete to the terminal box excluding power leads for the centrifuge drive motors. Wire runs from machine mounted electrical control components to the machine mounted terminal box shall be rigidly mounted to the centrifuge frame. Main and scroll drive motor field connections shall be flexible, meeting all applicable electrical codes and provided by the CONTRACTOR.
- E. Guards for all gearboxes and belt drives shall be a minimum 11 gauge 316 stainless steel and shall be designed to OSHA standards. Completely enclose the entire belt drive system and construct to minimize vibration.
- F. Handmade electrical connections made in the field will not be allowed.

2.04 INSTRUMENTATION AND CONTROL

A. Refer to Division 17 – Instrumentation. Refer to the Instrumentation Drawings for the Process Mechanical Instrumentation Diagram for the Thickening System control.

B. Centrifuge Control Panel

1. All instrumentation equipment provided shall be the exact same as the instrumentation installed under the Hornsby Bend Biosolids Management Plant Thickener Complex Rehabilitation (March 2018) unless otherwise noted or unless coordinated with Owner/Engineer.
2. The Centrifuge Manufacturer shall provide and the CONTRACTOR shall install an industrial grade Centrifuge Control Panel in the proposed Electrical Room for each centrifuge. This panel will provide instrumentation process controls for the centrifuges and all ancillary equipment specified by the Centrifuge Manufacturer. The panel shall meet the requirements of Section 17400 – Instrument Panels and shall be provided in a 316 stainless steel NEMA 4X enclosure. The panel shall be installed as shown on the Drawings and specified herein.
3. The Control Panel shall include a programmable logic controller, 24vdc power supply, control power transformer, control relays, I/O terminal blocks, surge protector, door mounted pushbuttons, selector switches, indication light and one color touch screen Operator Interface Unit (OIU). All door mounted components included graphic OIU shall be heavy duty rated.
4. The panel shall include one (1) installed DIN rail mounted Ethernet Switch. The Ethernet switch shall be industrial rated 10/100Mbps switch. The switch shall be CISCO IE-2000 product line.
5. The PLC CPUs shall support not less than 12MB user memory. The actual amount of user memory required shall be adequate for the functions to be performed, plus an allowance of 100% for future expansion. The PLC shall also include Ethernet 10/100 Base-T TCP/IP communication port.

Description	Manufacturer	Module Number
Power Supply	Schneider Electric	BMXCPS2000
CPU: 4MB memory minimum. 1 Modbus ports, 1 USB, 1 Ethernet TCP/IP port, 8MB flash memory card by CPU Manufacturer	Schneider Electric	BMXP342020
DI Module: 115Vac 16 inputs	Schneider Electric	BMXDAI1604
DO Module: Relay 8 outputs	Schneider Electric	BMXDRA0805
AI Module: 8 channel inputs	Schneider Electric	BMXAMI0810
AO Module: 4 channel outputs,	Schneider Electric	BMXAMO0410
Ethernet Module	Schneider Electric	BMXNOE0100 BMXNOC0401
PLC RACK 12 slot	Schneider Electric	BMXXBP1200

6. The panel door-mounted OIU shall have a minimum 15-inch color touch screen. The OIU shall be SE Harmony with an HMIDT732 display, HMIG3U GTU, and an HMIZDCOV7 cover.

7. The panel shall have a 1KVA UPS to provide emergency power supply for the PLC and OIU. The manufacturer and model shall be APC smart-UPS SRT1000XLA. UPS shall be mounted on a UPS stand and installed inside the panel.
8. The panel shall be completely wired and tested, with terminal strips for external wiring connections. The Control Panel shall contain 10% spare analog and digital I/O. the I/O shall be wired to I/O field terminal.
9. All control panel wiring shall be SIS tinned to prevent corrosion. There shall be a minimum of 10% spare terminal connection points supplied. Refer to Section 17400 – Instrument Panels and Section 16200 – Wires, Conductors and Cables – 600V and Below for Austin Water's instrumentation panel cable and wiring requirements.
10. The centrifuge will be equipped with a vibration switch and a torque overload switch that will be interlocked with the controls to shutdown the centrifuge upon high-high vibration or torque overload.
11. Provide Control Panel PLC I/O mapping to the ENGINEER for the SCADA solids Thickening System monitor configuration.
12. Coordinate with the OWNER / SCADA Programming Engineer for the PLC clock SCADA time synchronization.
13. The PLC program shall not be password protected. CONTRACTOR shall provide the final PLC program to the OWNER.

C. Magnetic Flow Meter

1. Requirements:
 - a. Power Supply: 100-240VAC/24VAC/DC
 - b. Output: Input: 4-20mA HART, pulse/frequency/switch output
 - c. Housing: Remote, aluminum, coated
 - d. Cable, Remote Version: 100.00 ft coil + signal cable
 - e. Electrical Connection: Thread NPT1/2
 - f. Liner: Wastewater/Sludge application
 - g. Calibration Flow: 0.2%, 3-point
 - h. Customized Parameterization: Display; Totalizer
 - i. Minimum accuracy required: +/- 1.5%.
 - j. Ambient temperature: -5° – 140°F
 - k. Suitable for flooded condition
 - l. Sensor element shall be submersible rated
2. Required Accessories and Options
 - a. Display unit: required and NEMA 4X enclosure.
 - b. Surge Protection: Surge protector with 316 Stainless Steel connection
3. Pipe size: per mechanical drawings showing pipe size.
4. MANUFACTURERS and Models:
 - a. Rosemount Model: 8750W, same model as the Hornsby Bend Biosolids Management Plant Thickener Complex Rehabilitation (March 2018) flow meter.
5. Instrument list:

TAG	LOCATION	RANGE	UNIT
FIT-TC01-03A1	Centrifuge No. 1 Thickener Feed	0~1000	GPM

FIT-TC01-03A2	Centrifuge No. 2 Thickener Feed	0~1000	GPM
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D. Microwave Total Solids Transmitters

1. Requirements:
 - a. Power Supply: 100-240VAC/24VAC/DC
 - b. Output: Input: 4-20mA HART
 - c. Cable, Remote Version: signal cable 30 ft
 - d. Liner: Wastewater/Sludge application
 - e. Minimum accuracy required: repeatability +/- 0.01%TS.
 - f. Ambient temperature: -5° – 140°F
2. Required Accessories and Options
 - a. Display unit: required and NEMA 4X enclosure.
 - b. Surge Protection: Surge protector with 316 Stainless Steel connection
3. Pipe size: per mechanical drawings showing pipe size.
4. MANUFACTURERS and Models:
 - a. Valmet Model: TS FT-150/6", TS FT-150/8"
5. Instrument list:

TAG	LOCATION	RANGE	UNIT
AIT-TC01-100	Centrifuge 1 Inlet Solids Analyzer	0~10.0	%
AIT-TC01-101	Centrifuge 1 Discharge Solids Analyzer	0~10.0	%
AIT-TC01-200	Centrifuge 2 Inlet Solids Analyzer	0~10.0	%
AIT-TC01-201	Centrifuge 2 Discharge Solids Analyzer	0~10.0	%

E. Sludge Chute Level Indicating Transmitter

1. Requirements:
 - a. Protection: IP68 rated. Corrosion-resistant housing.
2. Level Indicating Transmitter Controller
3. MANUFACTURERS and Models
 - (i) Siemens Model: HydroRanger 200
4. Instrument list:

TAG	LOCATION	RANGE	UNIT
LIT-TC01-011	Centrifuge 1 Discharge Chute Level	0~10.0	ft
LIT-TC01-012	Centrifuge 2 Discharge Chute Level	0~10.0	ft

F. Sludge Chute Float Level Switch

1. Requirements
 - a. Mercury free switch
 - b. A float switch shall be furnished to automatically detect a high liquid level. The switch shall be normally closed and open on a rising liquid level. The float switch and piping shall be submersible. The junction box shall be NEMA 4X. All construction shall be of PVC, PBT, and Buna N for corrosion resistance.
 - c. NEMA 4X cast aluminum submersible enclosure
 - d. Rating: contact rated 5 amp minimum

2. Manufacturer
 - a. Magnetrol FLS
3. Instrument list:

TAG	LOCATION	RANGE	UNIT
LSH-TC01-011	Centrifuge 1 Discharge Chute Level Switch	-	-
LSH-TC01-021	Centrifuge 2 Discharge Chute Level Switch	-	-

G. Local Operation Station

1. Provide local operation stations for the centrifuges as shown on the Drawings. The local operation station shall be labeled as shown on I-1 drawing.
2. The local operation station shall meet following requirements:
 - a. Stainless steel 316 NEMA 4X 14 gauge minimum enclosure. Enclosure shall have same size as phase 1 provided enclosure: 24" X24"X9 1/2" (WHD). Enclosure shall meet UL 508A requirements and listed.
 - b. Magelis OIU same model as specified 2.04 B. 6 and has plastic cover for harsh environment with IP67 rated.
 - c. Enclosure shall have heavy-duty Estop push button. Button shall be Rockwell Automation 800HC-TFRX6A4.
 - d. Enclosure shall have a horn and beacon for alarm notification. Beacon shall be Allen-Bradley 855BS-N35BL4 and horn shall be Vibratone Horns 450-024-031.
 - e. Enclosure component such as circuit breaker, wires and cables, wire color, grounding, power supply, and terminal blocks shall meet same requirements as control panel in this specification.
 - f. Provide panel corrosion protection. The device shall be VpCI-111 by Calbrite Stainless Steel Conduit System

H. OIU Program Requirements

1. Coordinate with the OWNER for OIU design requirements for equipment tagging, screen convention, animation and color convention, alarm and trending management and security configuration.
2. Provide all required OIU screens. Screens shall include Thickening System overview screens, equipment configuration screens, alarms and summary screens, and trending screens.
3. All field analog signals shall be data-logged. Equipment run, fail and critical event shall be data-logged.
4. Provide trending screen for each analog historian data display.
5. OIU clock shall be synchronized with the PLC time.
6. Provide an alarm and event summary screen. Each alarm and event shall be date/time-logged.
7. Provide security configuration on the OIU. Security levels shall include visitor, operator, supervisor and administrator. Coordinate with the OWNER for each user login and operation and control privileges.

8. Provide an auto-logout function. The OIU shall automatically logout after five (5) minutes without operation activity.
 9. Provide a screen saver function. The OIU screen saver shall be turned on after ten (10) minutes without operation activity.
 10. The OIU configuration and program shall not be password protected. Provide the final OIU configuration and program to the OWNER.
- I. Operation Station functions on the front of the Centrifuge Control Panel shall, as a minimum, include:
1. Thickening System Control Power shall be a hardwired pushbutton. OIU status indication for:
 - a. System Control Power "On"
 - b. Auto Start "Starting in Auto"
 - c. Auto Stop....."Stopping in Auto"
 - d. CIP (Clean in Place) "Running in CIP"
 - e. Centrifuge....."Running"
 - f. Washwater Solenoid "Open"
 - g. Polymer Metering Pump "Running"
 - h. Macerator "Running"
 - i. Sludge Feed Pump....."Running"
 - j. Sludge Discharge Pump....."Running"
 - k. Cover "Closed"
 - l. Alarms
 - (i) Emergency Stop....."Fault"
 - (ii) Bowl Drive VFD "Fault"
 - (iii) Bowl Drive Motor Temperature....."Fault"
 - (iv) Back Drive VFD "Fault"
 - (v) Back Drive Motor Temperature "Fault"
 - (vi) Back Drive High Torque "Fault"
 - (vii) Back Drive High-High Torque "Fault"
 - (viii) High Vibration....."Fault"
 - (ix) High-High Vibration "Fault"
 - (x) Low Relative Speed "Fault"
 - (xi) Polymer System "Fault"
 - (xii) Macerator....."Fault"
 - (xiii) Sludge Feed System "Fault"
 - (xiv) Sludge Discharge Pump "Fault"
 - (xv) Cover Open, if applicable "Fault"
 - m. OIU Digital Speed, Flow Indication of:
 - (i) Bowl Speed..... "RPM"
 - (ii) Back Drive Speed "RPM"
 - (iii) Back Drive Torque....."Percent"
 - (iv) Relative Speed "RPM"

- (v) Vibration "In/Sec"
- (vi) Polymer Feed..... "GPM"
- (vii) Sludge Feed..... "GPM"
- (viii) Centrifuge Drive Motor Pumps..... "Amps"

n. OIU Speed Control for:

- (i) Bowl Speed
- (ii) Scroll Relative Speed (PI Manual)
- (iii) Scroll Torque (PI Auto)
- (iv) Polymer Metering Pump
- (v) Sludge Feed Pump
- (vi) Sludge Discharge Pump

2. Interface Requirements

a. Centrifuge Control Panel

- (i) Power input from customer supply
 - (a) 460 VAC, 3-phase, 60 Hz, 70 amps
- (ii) Power output to centrifuge drive motors
 - (a) Bowl drive motor
 - (b) Backdrive motor
- (iii) Inputs from centrifuge motors (dry contact)
 - (a) Bowl drive motor thermostat
 - (b) Backdrive motor thermostat
- (iv) Inputs from machine junction box (dry contact)
 - (a) Backdrive high-high torque overload limit switch
- (v) Inputs from Centrifuge Manufacturer Provided equipment (dry contact)
 - (a) Macerator run confirm
 - (b) Macerator HOA status
 - (c) Macerator fault
 - (d) Sludge Feed Pump run confirm
 - (e) Sludge Feed Pump HOA status
 - (f) Sludge Feed Pump fault
 - (g) Sludge Discharge Pump run confirm
 - (h) Sludge Discharge Pump HOA status
 - (i) Sludge Discharge Pump fault
- (vi) Inputs from existing equipment (dry contact)
 - (a) Polymer metering pump run confirm
 - (b) Polymer metering pump fault
- (vii) Inputs from machine junction box (4-20 mADC signal)
 - (a) Centrifuge vibration
 - (b) Tacometer
- (viii) Inputs from existing equipment (4-20 mADC signal)
 - (a) Polymer Metering Pump flow

- (ix) Inputs from Centrifuge Manufacturer provided equipment (4-20 mADC signal)
 - (a) Sludge Feed Pump flow
- (x) Outputs to field mounted devices
 - (a) 120 VAC washwater solenoid power (open command)
- (xi) Outputs to equipment (dry contact)
 - (a) Polymer Metering Pump run command (includes E-Stop)
 - (b) Macerator run command (includes E-Stop)
 - (c) Sludge Feed Pump run command (includes E-Stop)
 - (d) Sludge Discharge Pump run command
- (xii) Outputs to equipment (4-20 mADC signal)
 - (a) Polymer Metering Pump speed reference
 - (b) Sludge Feed Pump speed reference
- b. Description of Operation
 - (i) The emergency stop will de-energize the master control relay to interrupt all run commands for immediate shutdown. To restart Thickening System, the emergency stop(s) must be manually reset.
- c. Starting/Stopping Modes
 - (i) Manual mode – Components shall be started with their respective start pushbuttons which can be accessed through the touch screen.
 - (ii) Auto mode – Startup and shutdown shall be controlled from the auto start/auto stop pushbuttons. Operating the auto start pushbutton will initiate the sequence of events described herein. At any time while in the Auto mode, the operator can begin a startup or shutdown.
 - (iii) Operating the Auto Start pushbutton will initiate the following sequence of events:
 - (a) Centrifuge bowl drive starts (instantly)
 - (b) Centrifuge back drive starts (3-second delay, field adjustable, from bowl starting)
 - (c) Polymer Metering Pump starts (once bowl and back drive come to speed)
 - (d) Sludge Feed Pump starts
 - (e) Macerator starts
 - (f) Sludge Discharge Pump starts
 - (iv) While Auto start is in progress, the Auto start indicator light will flash "STARTING IN AUTO". After startup is complete, the indicator light will stay on steady "RUNNING IN AUTO".
 - (v) Operating the Auto Stop pushbutton will initiate the following sequence of events:
 - (a) Sludge Feed Pump stops (instantly)
 - (b) Macerator stops (instantly)
 - (c) Polymer Metering Pump stops (instantly)
 - (d) Centrifuge goes to relative speed control (instantly)

- (e) Centrifuge goes to auto stop preset speed #1 (at normal deceleration ramp)
- (f) Washwater valve opens (once centrifuge is at preset speed #1)
- (g) Sludge Discharge Pump stops
- (h) Centrifuge remains at this (duration as preset speed No. 1 predetermined, field adjustable)
- (i) Centrifuge goes to auto (at normal stop preset speed #2 deceleration ramp)
- (j) Centrifuge remains at this (duration as predetermined, field adjustable)
- (k) Centrifuge stops (at normal deceleration ramp)
- (l) Washwater valve closes (at bowl speed as predetermined, field adjustable)
- (vi) The washwater valve opens for a predetermined, field adjustable, time during shutdown.
- (vii) Auto stop indicator light will flash while stopping is in progress and go on steady when complete.
- (viii) CIP mode – Startup and shutdown can be controlled from the CIP start/stop pushbuttons. Operating the CIP start pushbutton will initiate the following sequence of events. At any time while in the CIP mode, the operator can begin a startup or shutdown.
 - (a) Centrifuge bowl drive starts (instantly)
 - (b) Centrifuge back drive starts (3-second delay from bowl run confirm)
 - (c) Washwater valve opens (once bowl and scroll come to speed)
- (ix) The duration and speeds for the CIP cycle are field adjustable. Operating the CIP Stop pushbutton will initiate the following sequence of events:
 - (a) Washwater valve closes (instantly)
 - (b) Stop Centrifuge (at normal deceleration ramp)
- d. Alarms
 - (i) Alarm conditions shall be indicated with green indicators on the alarm screen and shall cause alarm horn to sound and beacon to flash. Alarm lights will go on steady as long as condition is still in fault condition. Operation acknowledge pushbutton will silence horn and cause indicator light to flash only if condition has been cleared. Operating reset button will clear alarm indicator and allow Thickening System startup.
 - (ii) Following conditions shall immediately shutdown the complete Thickening System in auto, manual, or CIP:
 - (a) CSP emergency stop
 - (b) COP emergency stop
 - (c) Bowl drive VFD fault
 - (d) Bowl motor high temperature
 - (e) Back drive VFD fault
 - (f) Back drive motor high temperature

- (g) Back drive high-high torque
 - (h) High-High vibration
 - (i) Cover open
 - (iii) Following conditions shall shutdown polymer and sludge feed in auto mode:
 - (a) High vibration
 - (b) Back drive high torque
 - (c) Polymer system fail
 - (d) Macerator fail
 - (e) Sludge Feed Pump fail
 - (f) Sludge Discharge Pump fail
 - (g) Low relative speed
 - (h) Open cover
 - (iv) High vibration or high torque will initiate a flush sequence the duration of which is operator adjustable. If three (3) high vibration or high torque alarms occur within a field adjustable time limit, an auto stop sequence shall be initiated. If the alarm clears, the polymer metering and sludge pumps will be restarted in auto mode.
 - (v) These alarm set points are field adjustable.
 - e. Control panel shall be provided with battery back-up power supply.
 - f. Elapsed time meter shall be a six (6) digits, non-reset, register type with last digit reading in tenths of an hour.
 - g. Chute level transmitter: The level reading shall be used for control of the sludge level in the chute by modulating the sludge discharge pump VFD speed.
 - h. Chute Level High Alarm: The level high alarm and switch shall be used to shut down the Thickening System when the chute high level condition occurs.
- J. Existing Centrifuges (CE-300, CE-400, and CE-500)
1. Provide inlet valve actuator for CE-300, CE-400, and CE-500 existing 8-inch plug valve per Section 15204 – Electric Valve Operators.
 2. Valve tags shall be:
 - a. Centrifuge 3 Inlet Valve: PV-TC01-031
 - b. Centrifuge 4 Inlet Valve: PV-TC01-041
 - c. Centrifuge 5 Inlet Valve: PV-TC01-051
 3. Each valve shall have same IO and control as shown on the CE-100 and CE-200 PMID.
 4. Provide local control panel PLC/OIU program for valve status monitor and control. Valve shall be able to be operated from local control panel OIU and SCADA HMI when valve Local-Off-Remote select switch is at Remote
 5. Provide all control wires and conduits to the centrifuge control panel.

2.05 PAINTING

- A. Equipment, frames, baseplates, appurtenances, etc., shall receive surface preparation, prime coating, and finish coating in the factory prior to shipment in accordance with

applicable requirements of Section 09900 – Painting, unless otherwise noted herein or on the Drawings. Ductile iron piping and fittings shall be shop prepared and primed by the Centrifuge Manufacturer, and field primed and finish coated by the CONTRACTOR. Valves shall be shop prepared, primed and have one (1) finish coat in the factory on the exterior, and the interior shall be finish coated in the factory with epoxy type coating. The CONTRACTOR shall apply a second finish coating in the field to all valves and piping, and touchup paint to the equipment. Colors shall be selected by the OWNER during submittal reviews.

- B. All centrifuge carbon steel surfaces shall be painted / coated to a minimum of the following:
 - 1. Minimum surface preparation of thorough removal of burrs, complying with SSPC-SP3 standards, sandblasting complying with SSPC-SP5 standards and complete grease removal.
 - 2. A minimum of one (1) coating of primer utilizing a two-part, zinc chromate epoxy, anti-rust primer meeting AFNOR: FAMILY I Class 6B requirements. Each coat shall have a dry film thickness of 2.5 to 3.0 mils.
 - 3. A minimum of one (1) paint undercoat of epoxy, phenolic, polyamide coating meeting AFNOR FAMILY I Class 6B requirements with a minimum dry film thickness of 4 to 6 mils.
 - 4. One (1) finish coat of epoxy, phenolic, polyamide coating meeting AFNOR FAMILY I Class 6B with a minimum dry film thickness of 4 to 6 mils.
 - 5. Total thickness of coatings must be a minimum dry film thickness of 12 mils.

PART 3 EXECUTION

3.01 FABRICATION AND ACCEPTANCE

- A. The thickening centrifuge units specified herein shall be factory assembled, complete with all components specified.
- B. A factory test shall be conducted of the centrifuge unit operation, including PLC graphics and control logic and the following:
 - 1. Noise Level Test
 - a. The average noise level measured at three (3) feet around the periphery of the complete centrifuge assembly shall not exceed 85dBa when tested without feed and with the inlet and discharge ports closed.
 - 2. Vibration Test
 - a. The centrifuge, when running without feed, shall be measured for vibration in the manufacturing facility. The vibration displacement shall be less than 2 mils (6.5 mm/sRMS) when measured at the pillow blocks under dry shop test conditions.
- C. Provide written notice to the ENGINEER of successful completion of the factory and vibration tests at least 30 days prior to shipment of the units. The OWNER and ENGINEER shall have the opportunity to inspect and test the units at the factory prior to packing/package for shipment.

- D. The OWNER (two (2) persons) and the ENGINEER (one (1) person) will witness the factory test. The CONTRACTOR shall provide the following for the OWNER and ENGINEER:
 - 1. Air travel to/from the testing facility and the local airport. The flight shall be non-stop from and to the nearest airport. Provide business class airline tickets for flights over three hours. Provide business class airline tickets for flights outside the Continental USA.
 - 2. Lodging, meals and ground transportation.

3.02 FIELD QUALITY CONTROL

- A. Verify that structures, pipes and equipment are compatible.
- B. Place the Thickening System in proper operating condition.
- C. The Centrifuge Manufacturer's factory certified service technician shall:
 - 1. Provide certificates for proper installation which states that the equipment meets all the design and performance requirements of this Specification before operation.
 - 2. Perform Start-Up test, functional test and acceptance test; and operate the Thickening System to verify satisfactory operation of each thickening centrifuge unit in presence of OWNER and ENGINEER's personnel, and provide certified field test reports as specified herein. Check units for excessive noise, vibration, alignment, general operation, etc. Excessive noise or vibration shall be cause for rejection of equipment.

3.03 INSTALLATION

- A. All components and accessories of the Thickening System shall be installed in accordance with the Centrifuge Manufacturer's written instructions and recommendations, as approved by the ENGINEER, and as shown on the Drawings. Mount systems as indicated. Do not begin fabrication or erection prior to submittal and shop drawings approval.
- B. The CONTRACTOR shall be responsible for the installation of the equipment and the associated piping and electrical to complete the Thickening System for operation in accordance with the Centrifuge Manufacturer's instructions and approved shop drawings.
- C. The CONTRACTOR shall be responsible for installing equipment that the Centrifuge Manufacturer could not ship assembled as an integral part of the Thickening System due to shipping restrictions. These items shall be identified on the Centrifuge Manufacturer's approval drawings.
- D. No field welding, except seal welding to provide specific degree of tightness against leakage, will be allowed.
- E. 316 stainless steel anchor bolts shall be as specified by the Centrifuge Manufacturer and furnished and installed by the CONTRACTOR in accordance with the Centrifuge Manufacturer's recommendations. Installation shall include furnishing the required oil

and grease for initial operation. The grades of oil and grease shall be in accordance with the Centrifuge Manufacturer's recommendations.

- F. The Centrifuge Manufacturer's factory certified service technician shall inspect the complete installation and provide written certification stating that the installation of the equipment is satisfactory. The certification must also indicate the equipment is ready for operation and that the operating personnel have been suitably instructed in the operation, lubrication and care of the system.
- G. Odor Duct System Connections
 1. Centrifuge odor ducts shall be PVC, Schedule 80. PVC shall conform to ASTM D-1784-95 Class 12454-B, with a flame spread rating below 20 and smoke development rating below 50.
 2. Centrifuge odor ducts shall connect to the main odor duct header shown on the Drawings.
 3. All connections to the centrifuge and to the main odor duct header are to be isolated with flexible connectors to eliminate any rigid joints.
 4. Centrifuge odor ducts shall be independently supported from the ground or the Manufacturer provided FRP platform without limiting operator access in the along the FRP platform, the centrifuge discharge access trench or on the west walkway of the Thickener Complex. Odor ducts supports should match the layout of the existing centrifuge odor ducts.
 5. The CONTRACTOR shall submit detailed drawings of the odor duct system plan, including duct layout, sizes and number and location of supports for approval by the OWNER and ENGINEER.

3.04 POLYMER TESTING

- A. The Centrifuge Manufacturer shall be responsible for testing sludge and polymer to be used in Start-Up and for Acceptance Testing. Polymer jar testing shall be performed to determine the optimal polymer type for the sludge.
- B. The polymer testing shall include conducting jar tests with various polymers at different solution concentrations. The cost of the polymer for jar testing will be borne by the Centrifuge Manufacturer. A minimum of two (2) types of polymer each from three (3) polymer manufacturers is required for testing. All new polymer types tested shall be liquid emulsion polymers. The Centrifuge Manufacturer shall also test the current polymer utilized at the Thickener Complex.
- C. The Centrifuge Manufacturer shall submit polymer testing results and recommended selection to the OWNER and ENGINEER for review and acceptance prior to Start-Up and Acceptance Testing of any of the Thickening Systems.

3.05 THICKENING SYSTEM START-UP, TESTING AND INSPECTION

- A. Each Thickening System shall undergo Start-Up and acceptance testing. Depending on the sludge availability and construction sequencing, each of the two (2) Thickening Systems may undergo Start-Up / acceptance testing simultaneously or separately. The CONTRACTOR and Centrifuge Manufacturer shall coordinate field service work with the

Centrifuge Manufacturer's factory certified service technician, OWNER and ENGINEER prior to initiating such work. The Centrifuge Manufacturer shall furnish the services of factory-trained technician(s) experienced in the installation and operation of the Thickening Systems.

B. Start-Up

1. The Centrifuge Manufacturer shall submit a Start-Up test procedure and schedule to the OWNER and ENGINEER for approval. The Start-Up test procedure and schedule shall include Start-Up of each Thickening System. The polymer feed and associated pumps / system will be provided by the OWNER (at the OWNER's expense).
2. Start-Up will begin only when the Start-Up test procedure and schedule have been reviewed and approved by the OWNER and ENGINEER.
3. The CONTRACTOR, Centrifuge Manufacturer, Centrifuge Manufacturer's factory certified service technician or engineer, OWNER's trained personnel and ENGINEER shall be present for Start-Up testing.
4. The Centrifuge Manufacturer's factory certified service technician or engineer shall be available on site for the tuning, monitoring, optimization and restarting of each Thickening System during the entire Start-Up test duration. In addition, a factory certified technician shall be present from the installed macerator, sludge feed pump and sludge discharge pump Manufacturers for Start-Up testing.
5. The OWNER shall provide (at the OWNER's expense), trained personnel, water, polymer and electrical power.
6. The thickened sludge produced during the Start-Up testing will be conveyed to the Blend Tank per the Drawings. If during the Start-Up testing the thickened sludge is not acceptable to the OWNER for processing, the Start-Up testing shall be halted until adequate adjustments can be made to achieve acceptable thickened sludge.
7. The Start-Up procedure shall include:
 - a. To begin initial Start-Up, the macerator, sludge feed pump, centrifuge and discharge pump shall be tuned and adjusted to undergo operation. Subsequent to proper tuning, and initial thorough inspection of all Thickening System components, including electrical and instrumentation controls, will be performed. Faulty components of the macerator, sludge feed pump, centrifuge and / or sludge discharge pump found during initial inspection shall be repaired and replaced within forty-eight (48) hours by the Centrifuge Manufacturer at no cost to the OWNER.
 - b. Subsequent to initial inspection, each Thickening System shall be operated at a minimum of forty-eight (48) hours of continuous operation. If no malfunctions occur during the forty-eight (48) hours of continuous operation, the initial Start-Up testing shall be deemed complete.
 - c. If malfunctions occur during the forty-eight (48) hours of continuous operations, the Centrifuge Manufacturer shall perform corrective action within forty-eight (48) hours and restart the centrifuge for a minimum of ninety-six (96) hours of additional continuous operation. If no problems are evident during the ninety-six (96) hours of subsequent operation, the Start-Up testing shall be deemed complete.

- d. If malfunctions occur during the ninety-six (96) hours of subsequent continuous operation, the Start-Up period shall be terminated and the Centrifuge Manufacturer shall perform corrective action within forty-eight (48) hours prior to requesting an additional Start-Up test. If an additional Start-Up test is necessary, it shall follow the same procedure as specified above and be subject to the OWNER's approval. The satisfactory completion of the Start-Up test shall be at the discretion of the OWNER and ENGINEER.

C. Acceptance Testing

1. Upon satisfactory completion of the installation, Start-Up and instruction phase of the Thickening System, an installed Acceptance Test shall be performed by the Centrifuge Manufacturer on each Thickening System and be witnessed by the OWNER and ENGINEER. The Acceptance Test shall be conducted to demonstrate to the OWNER and ENGINEER that the installed Thickening System can successfully operate as a system as specified and shall provide the Centrifuge Manufacturer the necessary operating time to optimize the centrifuge unit performance.
2. The OWNER shall provide (at the OWNER's expense), trained personnel, water, polymer and electrical power.
3. The Centrifuge Manufacturer shall perform an analysis, to the OWNER's satisfaction, during the Acceptance Test, to determine if the following design parameters / requirements are consistent with the Specifications for not less than 95 percent of the time of the Acceptance Test. For non-continuous data from SCADA, samples / readings shall be obtained every ten (10) minutes for the duration of the Acceptance Test.
 - a. Influent solids content: normal range of 1.0-2.5% dry solids by weight with a potential maximum value of 3.5%
 - b. Thickened Solids content:
 - (a) Design: 6% dry solids by weight
 - (b) Minimum: 5.5% dry solids by weight
 - (c) Maximum: 6.5% dry solids by weight
 - c. Design solids capture rate equal to a minimum 95% of feed total solids by dry weight at design feed rate and normal dry solids range.
 - d. Polymer consumption equal to a maximum of 6 active pounds per ton thickened sludge at design feed rate and normal dry solids range.
 - e. Vibration displacement shall be less than 2 mils (6.5 mm/sRMS) when measured at the pillow blocks under dry test conditions.
4. The Centrifuge Manufacturer shall perform an analysis during the Acceptance Test to determine the power consumption (in kW) of the centrifuge unit. For non-continuous data from SCADA, readings shall be obtained every ten (10) minutes for the duration of the Acceptance Test.
5. The CONTRACTOR and Centrifuge Manufacturer, with the assistance of the OWNER's personnel, shall place all components necessary for the operation of the Thickening System into successful operation.
6. The Acceptance Test shall occur on a normal weekday between the hours of 7:00 AM and 3:00 PM CST for a minimum of six (6) continuous hours. The Centrifuge Manufacturer shall be allowed to operate the Thickening System to determine the

optimum operating conditions prior to the time of the acceptance testing. The Centrifuge Manufacturer shall work with the OWNER during this period to provide further equipment training and troubleshooting procedures.

7. If the equipment meets the specified requirements, the ENGINEER will recommend to the OWNER, in writing, with a copy to the CONTRACTOR and Centrifuge Manufacturer, the official acceptance of the Thickening System. If the acceptance tests do not meet the requirements specified, the ENGINEER shall notify the OWNER and the Centrifuge Manufacturer, in writing, of the non-acceptable performance of the Thickening System, namely the centrifuge. In the event of non-acceptable performance, the Centrifuge Manufacturer shall then have thirty (30) days to perform supplemental equipment changes, adjustments, additions or modifications and request a re-test of the non-acceptable Thickening System. All expense of re-testing the units shall be borne by the CONTRACTOR.

3.06 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.
 1. Progress payments for the centrifuge unit order value shall be provided to the CONTRACTOR as reimbursement for progress payments made to the Centrifuge Manufacturer as outlined in Section 01025 – Measurement and Payment.

END OF SECTION

SECTION 15000

SPECIAL CONDITIONS FOR MECHANICAL WORK

PART 1 GENERAL

The work to be accomplished under these specifications includes all labor, materials and equipment required for the complete installation as described herein and as indicated on the mechanical Drawings for the project. Drawings, General and Supplementary Conditions, and General Provisions, Division 1 Specification Sections, apply to work herein.

1.01 SPECIAL CONSIDERATIONS

- A. Anything mentioned in the specifications and not shown on the Drawings, or shown on the Drawings and not mentioned in the specifications, shall be provided as though shown and mentioned in both.
- B. Coordinate the mechanical work with all other trades to determine whether there will be any interference by such trades with the mechanical work.
- C. Investigate structural and finish conditions and arrange work accordingly, furnish all fittings and accessories required to meet conditions and give satisfactory operation. Coordinate with other Subcontractors to avoid interference with their work. The right to make any reasonable change in the location of outlets, apparatus, and equipment up to time of roughing-in is reserved by the OWNER's Representative without involving any additional expense to the OWNER.

1.02 SITE INSPECTION

- A. All bidders submitting proposals for the work shall first examine the site and all existing conditions. The lack of specific information on the Drawings shall not relieve the bidder's responsibility for taking into account all site conditions in the proposal.

1.03 CODES, STANDARDS AND PERMITS

- A. Work to conform to the latest editions of the following:
 - 1. ASHRAE.
 - 2. All applicable city, state and national codes.
 - 3. Requirements of local utility companies.
 - 4. Underwriter's Laboratories, Inc., and shall be so labeled.
 - 5. NFPA.
 - 6. OSHA.
 - 7. Applicable AWWA Standards.
 - 8. Applicable ASTM Standards.
- B. In case of difference between applicable codes, specifications, utility company regulations and the Contract Documents, the most stringent shall govern.

- C. Obtain all permits, inspections and approvals applicable to the mechanical trade, as required by regulatory authorities. All fees and costs of any nature whatsoever incidental to these permits, inspections and approvals shall be assumed and paid. Obtain and pay for all the necessary certificates of approval, which shall be delivered to the ENGINEER before final acceptance of the work.
- D. The Manufacturer's published directions shall be followed in the delivery, storage, protection, installation, piping, and wiring of all equipment and material.

1.04 SHOP DRAWINGS AND SUBMITTALS

- A. Refer to Section 01300 – Submittals.

1.05 OPERATION AND MAINTENANCE MANUAL

- A. An operation and maintenance manual for each mechanical system and for each piece of equipment shall be furnished by the CONTRACTOR. The manual shall include, but not be limited to, the following:
 - 1. A system layout showing piping, valves, and controls.
 - 2. Wiring and control diagrams.
 - 3. A control sequence describing Start-Up, operation and shutdown.
 - 4. Installation instructions.
 - 5. Maintenance and overhaul instructions.
 - 6. Lubrication schedule including type, grade and temperature range, and frequency.
 - 7. Parts lists.
 - 8. Local Supply or otherwise.

1.06 MATERIALS AND MANUFACTURERS

- A. Materials furnished shall be of best quality and grade of standard Manufacturer, shall conform to the National Board of Fire Underwriters requirements, and shall bear the Underwriters' seal of approval.
- B. Each item of equipment shall fit plan and space allowed and surrounding conditions and fulfill completely the function for which it is intended as well as item named on Drawings or in specifications.

1.07 CONCRETE EQUIPMENT FOUNDATIONS, BASES, AND ROOF CURBS

- A. All concrete equipment foundations, bases, and roof curbs as required for the installation of mechanical work hereinafter specified shall be furnished and installed by the CONTRACTOR. The trade installing the mechanical sections of the work shall be responsible for the proper coordination of its equipment with these bases. Furnish all anchor bolts and other accessories required for casting in these concrete bases.

1.08 PROTECTION OF MATERIALS AND APPARATUS

- A. At all times, the CONTRACTOR shall take such precautions as may be necessary to properly protect the apparatus from damage. This shall include the creation of all

required temporary shelters to adequately protect any apparatus and the covering of apparatus in the complete building with tarpaulins or other protective covering.

1.09 SPACE AND EQUIPMENT ARRANGEMENT

- A. The size of equipment shown on the Drawings is based on the dimensions of a particular Manufacturer. Where other Manufacturers are acceptable, it is the responsibility of the CONTRACTOR to determine if the equipment proposed to be furnished will fit the space available. Shop drawings shall be prepared by the CONTRACTOR when required by the OWNER's Representative or ENGINEER to indicate a suitable arrangement.
- B. All equipment shall be installed in a manner to permit access to all surfaces requiring access. Proper clearances shall be maintained to meet all safety and operating codes.

1.10 FLAME SPREAD PROPERTIES OF MATERIALS

- A. All materials and adhesives used for air conditioning filters, acoustical lining and insulation shall conform to NFPA and UL life and safety and flame spread properties of materials. The composite classifications shall not exceed 25 for a flame spread rating and 50 for a smoke developed rating for these classifications as listed for the basic materials, the finished, adhesives, etc., specified for each system and shall be such when completely assembled.

1.11 RECORDS FOR THE OWNER

- A. The CONTRACTOR shall keep a set of Drawings on the job, noting daily all changes made in these Drawings in connection with the final installation including exact dimensioned locations of all new and uncovered existing utility piping outside the building and shall, with the request for final payment, turn over a clean, neatly marked set of reproducible drawings showing "As Installed" work to the OWNER's Representative for subsequent transmittal to the OWNER.
- B. In addition to the above, the CONTRACTOR shall accumulate during the job's progress the following data, in duplicate, prepared in a neat brochure or packet folder and turned over to the OWNER's Representative for checking and subsequent delivery to the OWNER.
 - 1. All warranties, guarantees and Manufacturer's directions on equipment and material covered by the contract.
 - 2. Approved wiring diagrams and control diagrams.
 - 3. Copies of approved shop drawings.
 - 4. Test and Balance report.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 15047

MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The work included herein consists of furnishing all material, equipment, labor and performing all necessary operations for the mechanical identification of items as indicated on the Drawings and specified herein.
- B. The Work included is:
 - 1. Piping Identification
 - 2. Equipment Identification
 - 3. Ductwork Identification
 - 4. Valve Tags
 - 5. Valve Schedule
 - 6. Hazard Identification and Warning
 - 7. Signs

1.02 SUBMITTALS

- A. Submit in accordance with Division 1 – General Requirements.
- B. List of wording, symbols, letter size, and color coding for mechanical identification to be reviewed by ENGINEER and Hornsby Bend operations staff.
- C. Valve chart and schedule, including valve tag number, location, function, and valve Manufacturer's name and model number.
- D. Manufacturer's catalog literature for each product required.
- E. Samples of color, lettering style, and other graphic representation required for each identification device.

1.03 REFERENCE STANDARDS

- A. ASME 13.1 – Scheme for the Identification of Piping Systems
- B. International Institute of Ammonia Refrigeration (IIAR) Bulletin 114 – Guidelines for Identification of Ammonia Refrigeration Piping and System Component
- C. NFPA 99 C – Standard on Gas and Vacuum Systems
- D. Occupational Safety and Health Administration (OSHA) – Part 1910 Occupational Safety and Health Standards

1.04 QUALITY ASSURANCE

- A. Comply with ASME 13.1, "Scheme for the Identification of Piping Systems", for letter size, colors, and viewing angles of identification devices for piping.
- B. Acceptable Manufacturers:
 - 1. Brady Corporation – Milwaukee, Wisconsin
 - 2. Seton – Branford, Connecticut

1.05 COORDINATION

- A. Coordinate installation of identifying devices to ensure that mechanical identification is not painted over or covered. Install identifying devices prior to installation of acoustical ceilings and similar concealment.
- B. Where applicable, identifying devices shall be applied on access panels and doors.
- C. Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations shown on the Drawings. Submit all lettering for review prior to the manufacturing or ordering of mechanical identification.
- D. Use numbers, lettering, and wording indicated for proper identification and operation/maintenance of mechanical systems and equipment.

PART 2 PRODUCTS

2.01 PIPING IDENTIFICATION

- A. General: All exposed piping, unless specified otherwise, shall be painted according to the color code system specified, using paint materials, surface preparation, and application techniques specified in Division 9. All exposed piping shall have a product identification label applied to the piping. Where pipes are too small for such application, a brass identification tag shall be fastened securely at specified locations. Tags shall be a minimum 1-1/2-inch in diameter with depressed black figures of appropriate size.
- B. Existing Identification Systems
 - 1. In installation where existing piping systems have been established, the CONTRACTOR shall continue to use the existing system. Where existing identification systems are incomplete, utilize the existing system as far as practical and supplement with the specified system. The objective is to fully identify all new piping, valves, and appurtenances to the level specified herein.
- C. Identification Label
 - 1. Provide identification labels bearing the full piping system or appropriate abbreviation as shown on Mechanical Legend Drawings.
 - 2. Label shall be applied to the exterior covering of all piping, bare or insulated. Adequate number of labels shall be provided.
 - 3. Directional flow arrows shall be applied adjacent to each pipe marker.

4. Labels shall be manufactured and pre-printed. Labels shall be:
 - a. Pre-coiled, semi rigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive for piping less than six (6) inches in diameter.
 - b. Preformed, semi-rigid plastic formed to partially cover circumference of pipe and to attach to the pipe with mechanical fasteners that do not penetrate insulation vapor barrier for piping six (6) inches or greater in diameter.
5. Color of background and lettering shall comply with ASME 13.1.
6. Labels shall be placed so as to be easily read from operating positions. Location of labels on the piping shall be as follows:
 - a. Each branch and riser takeoff.
 - b. At each pipe passage through wall, floor and ceiling construction.
 - c. At each pipe passage to underground.
 - d. At not more than five (5) feet spacing on straight pipe runs.
 - e. At each valve, strainer and all pieces of equipment.
7. The letter sizes corresponding to the applicable outside diameter of pipe or pipe covering shall be used.

<i>Outside Pipe Diameter (Including Insulation)</i>	<i>Minimum Length of Label Color Field</i>	<i>Minimum Letter Height</i>
3/4" to 1-1/4"	8"	1/2"
1-1/2" to 2"	8"	3/4"
2-1/2" to 6"	12"	1-1/4"
8" to 10"	24"	2-1/2"
Over 10"	32"	3-1/2"

- D. Comply with TCEQ 217.329 standards for following piping color:

<i>Product/Legend</i>	<i>Color of Pipe</i>
Non Potable Water	Purple ¹
Sludge	Brown
Natural Gas	Red
Potable Water	Light Blue
Chlorine	Yellow
Sulfur Dioxide	Lime Green with Yellow Bands
Sewage	Grey
Compressed Air	Light Green

Heated Water	Blue ²
Power Conduit	NEC Electrical Code ³
Reclaimed Water	Purple with Black Lettering
Gray Water	Purple with Yellow Writing
Instrument Air	Light Green with Dark Green Bands
Liquid Alum	Yellow with Orange Bands
Alum (Solution)	Yellow with Green Bands
Ferric Chloride	Brown with Red Bands
Polymers	White with Green Bands
Ozone	Stainless Steel with White Bands
Raw Water	Tan
Effluent after Clarification	Dark Green

¹Non-potable water pipe must also be stenciled "NON-POTABLE WATER, DO NOT DRINK" and "NO BEBA EL AGUA".

²Heated water pipe must also have 6-inch red bands spaced 30 inches apart.

³Power conduit must be in compliance with the National Fire Protection Association 70 National Electrical Code®

1. CONTRACTOR to verify piping color with latest TCEQ criteria.
2. The OWNER will select the final colors during the submittal process. Any identification made prior to OWNER selection shall be at the CONTRACTOR's expense.

2.02 EQUIPMENT IDENTIFICATION

A. Equipment Nameplates

1. Provide professionally engraved nameplates for equipment. Nameplates shall be fabricated of 1/8-inch thick Type 316 stainless steel plate. The nameplates shall be attached to equipment body or frame base by fully threaded Type 304 stainless steel tamper resistant machine screws. Nameplate shall be located to be visible.
2. Data to be shown on nameplate shall include:
 - a. Manufacturer, product name, model number, serial number, and equipment number identified on the Drawings.
 - b. Capacity, operating and power characteristics, and essential data.
 - c. Year of manufacture.

B. Equipment Markers

1. Provide equipment markers for the following general categories of equipment:
 - a. Main control and operating valves, including safety devices.
 - b. Meters, gauges, and similar units.
 - c. Pumps, condensers and similar motor driven units.
 - d. Fans, blowers, and primary balancing dampers.
 - e. Packaged HVAC units.
 - f. Strainers, filters, humidifiers. And similar equipment.
2. Provide engraved, color-coded laminated plastic markers for equipment. Markers shall be contact-type, permanent adhesive. Marker size shall be a minimum 2-1/2 inches by 4-inches for control devices, dampers, and valves. Markers for equipment shall be a minimum of 4-1/2-inches by 6-inches.
3. Data to be shown on marker shall include:
 - a. Name of the equipment
 - b. Equipment service
 - c. Design capacity
 - d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.
4. Letter Size: Minimum 1/4-inch for name of units if viewing distance is less than 24 inches, 1/2-inch for viewing distance up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths of the size of principal lettering.

2.03 DUCTWORK IDENTIFICATION

- A. Ductwork Markers shall be engraved, color-coded laminated plastic. Include direction and quantity of airflow and duct service (such as supply, exhaust, and return). Include contact-type, permanent adhesive.
- B. Provide markers for air supply, exhaust, return, intake and relief ducts. Provide adequate number of markers to limit interval of markers to a maximum 50 feet.

2.04 VALVE TAGS

- A. Valve tags shall be stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme approved by the OWNER.
- B. Tags shall be brass, minimum 1-1/2-inch round, and having black lettering. Provide 5/32-inch hole for fastener. Fasteners shall be brass wire-link chain.

2.05 VALVE SCHEDULE

- A. For each piping system, on standard-size bond paper tabulate valve identification numbers, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal operating position (open, close or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

- B. Frame valve schedule in a glazed display frame or removable mounting on masonry walls for each page of valve schedule. Include mounting screws. Frame shall be extruded aluminum. Glazing shall be ASTM C1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single thickness glass.

2.06 HAZARD IDENTIFICATION AND WARNING

- A. All physical hazards within the scope of this Project shall be identified by signs or markings as required by OSHA and described in the Federal Register, Volume 37, No. 202, under Paragraph 1910.144, "Safety Color Code for marking Physical Hazards", Paragraph 1910.145 "Specifications for Accident Prevention Signs and Tags", and ANSI Z-535 latest available revision.
- B. Type or Class of Service:
 - 1. For attachment to smooth metal, painted or enameled surfaces, use self-sticking vinyl sign. This may also be used for message section on standard warning or directional signs.
 - 2. For attachment to rougher, porous surfaces, such as concrete or wood structures, chain link fencing, etc., use self-supporting fiberglass sign. When affixing to curved object such as rough pipe or pole, use polyethylene sign.
- C. Minimum Dimensions: Accident prevention signs shall be of OSHA standard dimensions, of the sizes specified by the OWNER. Dimensions are in inches, for horizontal pattern, height by width. For upright pattern, reverse the dimensions.
- D. Colors: Colors of signs, symbols and lettering shall comply with the requirements of OSHA 1910.145.

2.07 SIGNS

- A. General: Classification of accident prevention signs and tags (per OSHA):
 - 1. Danger Signs. White letters or red oval surrounded by rectangular black field in combination with specific message sections as called for in the Drawings or Project Manual.
 - 2. Caution Signs. Yellow letters on a black field in combination with specific message sections called for herein.
 - 3. Safety and Other Instructional Signs. The colors and design of instructional signs shall be red block capital letters on white background, with text and sizes as indicated herein.
 - 4. NFPA Placard. NFPA Diamond in combination with specific message sections (left diamond, top, right, and bottom) as called for herein. Placard shall be visible from the entrance point of each location.

PART 3 EXECUTION

3.01 PIPING IDENTIFICATION

- A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

- B. Locate pipe markers where piping is exposed in finished spaces, machine rooms, accessible maintenance spaces such as shafts, tunnels, and plenums, and exterior non-concealed locations.

3.02 EQUIPMENT IDENTIFICATION

- A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have a nameplate, or has a nameplate that is damaged or located where not easily visible.
- B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment.
- C. Locate markers where accessible and visible.

3.03 DUCTWORK IDENTIFICATION

- A. Locate markers in each space where ducts are exposed or concealed by removing ceiling system; locate signs near points where ducts enter into space and at maximum intervals specified herein.
- B. Relocate identifying devices which become visually blocked by work of this Division or another Division.

3.04 VALVE TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except plumbing fixture supply stops, shutoff valves, faucets, convenience and lawn watering hose connections, and similar roughing-in connections of end-use fixtures and units.

3.05 VALVE SCHEDULE INSTALLATION

- A. Mount valve schedule on wall in accessible location in each major equipment room.

3.06 SIGNS INSTALLATION

- A. Install signs at the locations specified herein.
- B. Signs shall be provided, but not limited, by the Schedule shown herein. Provide any additional signs as required by TCEQ and OSHA and all other regulatory agencies.

3.07 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 15107

SURGE ANTICIPATOR AND PRESSURE RELIEF VALVES

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required and install complete and ready for operation, and test the pressure relief valve and appurtenances as shown on the Drawings and as specified herein, and in accordance with the Contract Documents.

1.02 SUBMITTALS

- A. Submit materials required to establish compliance with these Specifications in accordance with Section 01300. Materials shall include the following:
 - 1. Certified drawings showing all important details of construction and dimensions.
 - 2. Descriptive literature, bulletins, and/or catalogs of the equipment.
 - 3. The total weight of each item.
 - 4. A complete bill of materials.
 - 5. Calculations confirming that valve size is proper for the system to be installed.
- B. Certificates and Test Reports:
 - 1. Certified test and installation results, if testing is required and not specified elsewhere.
 - 2. Additional submittal data, where noted with individual pieces of equipment.
 - 3. Certificates: For each valve specified to be manufactured and/or installed in accordance with AWWA and other standards, submit an affidavit of compliance with the appropriate standards, including certified results of required tests, and certification of proper installation.
 - 4. Submit appropriate affidavit of compliance that interior coating and surfaces of valve coming into contact with potable water are NSF61 certified.
- C. Operation and Maintenance Manuals: Operating and maintenance instructions shall be furnished as provided in Section 01730. The instructions shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions, and other information required to instruct operating and maintenance personnel unfamiliar with such equipment.

1.03 REFERENCE STANDARDS

- A. American Society for Testing and Materials (ASTM):
 - 1. ASTM A536 - Ductile Iron Castings.

1.04 QUALITY ASSURANCE

- A. Qualifications: Valves and appurtenances shall be products of well-established firms who are fully experienced, minimum five years, reputable and qualified in the manufacture of the particular equipment to be furnished. The equipment shall be designed,

constructed and installed in accordance with the best practices and methods and shall comply with these Specifications as applicable.

- B. Acceptable Manufacturers
 - 1. Cla-Val Company.
 - 2. Bermad.
- C. Services of Manufacturer's Representative
 - 1. Inspection, Startup, and Field Adjustment: The service representative of the valve Manufacturer shall be present at the Site for one work day, to assist the Contractor in the installation and adjustment of the valve(s).
 - 2. Instruction of Owners Personnel: The Training Representative of the valve Manufacturer shall be present at the Site for one work day to instruct the personnel in the operation, adjustment, and maintenance of the valve(s).
 - 3. For the purpose of this paragraph, a work day is defined as an eight hour period, excluding travel time.
- D. Inspection of the units may also be made by the Engineer or other representative of the Owner after delivery. The equipment shall be subject to rejection at any time due to failure to meet any of the Specification requirements, even though submittal data may have been accepted previously. Equipment rejected after delivery shall be marked for identification and shall be removed from the job site at once.

1.05 SYSTEM DESCRIPTION

- A. All of the equipment and materials specified herein is intended to be standard for use in controlling the treated water flow of fluids, depending on the individual systems, as noted on the Drawings. See all Drawings for valves.
- B. Valves, appurtenances and miscellaneous items shall be installed as shown on the Drawings and as specified, so as to form complete workable systems.

1.06 DELIVERY, HANDLING AND STORAGE

- A. Packing and Shipping:
 - 1. Care shall be taken in loading, transporting, and unloading to prevent injury to the valves, appurtenances, or coatings. Equipment shall not be dropped. All valves and appurtenances shall be examined before installation, and no piece shall be installed which is found to be defective. Any damage to the coatings shall be repaired as acceptable to the Engineer.
 - 2. Prior to shipping, the ends of all items shall be closed to prevent entry of foreign material.
- B. Storage and Protection: Special care shall be taken to prevent plastic and similar brittle items from being directly exposed to the sun, or exposed to extremes in temperature, to prevent deformation. See the individual piping Specifications and Manufacturer's information for further requirements.

1.07 MAINTENANCE

- A. Special tools and the Manufacturer's standard spare parts, if required for normal operation and maintenance, shall be supplied with the equipment.
- B. Provide all special tools required for normal maintenance. Tools shall be packaged in a steel case, clearly and indelibly marked on the exterior to indicate equipment for which tools are intended.
- C. Provide to the Owner a list of all spare and replacement parts with individual prices and location where they are available. Prices shall remain in effect for a period of not less than one year after start-up and final acceptance.

1.08 EXTENDED WARRANTY

- A. The valve and appurtenances shall be warranted for a period of three years from the date of Substantial Completion of the Project to be free of defects in materials and workmanship.

PART 2 PRODUCTS

2.01 FLANGED SURGE ANTICIPATOR AND PRESSURE RELIEF VALVES

- A. Surge anticipator and pressure relief valve shall be the highest quality provided by a reputable manufacturer. The valve manufacturer shall submit calculations conforming that valve is properly sized for application.
- B. The valve shall be designed to protect pipelines from pressure surges during power failure. The valve is to be installed on treated water pipeline.
- C. Valve Characteristics: The surge anticipator valve shall open when the inlet pressure drops below a set pressure level. It shall remain open and gradually close after a predetermined time. The pressure relief valve shall open when the inlet pressure exceeds above a set pressure level. The valve shall be a hydraulically operated, adjustable, pilot controlled, diaphragm valve as indicated. All necessary repairs shall be possible without removing the valve from the pipeline. Paragraph 2.01.I lists the operation conditions of the valve.
- D. Valve Body: The valve body shall be of stainless steel material. The valve cover shall be flanged and be of the same material as the body. The valve shall be designed for pressure rating of 250 psi.
- E. Valve Trim: The valve disc guide, seat and cover bearing, stem, spring, and all nuts, bolts, and washers shall be of Type 303 stainless steel. The valve stems shall have top and bottom guides. All rubber parts shall be of Buna-N. The diaphragms shall be of Nylon-reinforced Buna-N, supported firmly between the body and valve cover.
- F. Valve Controls: Existing valve controls shall be utilized. Valve shall be furnished to be compatible with existing controls.

- G. The valve shall have an indicator rod that is an integral part of the valve to show the position of the diaphragm within the valve body.
- H. All valves shall be equipped with a limit switch and contacts to monitor open status.
- I. Operating Conditions: The valve shall be designed to operate under the following conditions:
 - 1. Number of Valves..... 2
 - 2. Valve size (inches) 4 and 6
 - 3. Size of pipeline (inches diameter) 4 and 6
 - 4. Down Surge (Contractor to confirm parameters with Owner)
 - a. Opening pressure (psi).....30
 - b. Opening time (sec) 3
 - c. Fully open time (sec) 3
 - d. Closing time (sec)..... 150
 - 5. Up Surge (Contractor to confirm parameters with Owner)
 - a. Opening pressure (psi).....62
 - b. Opening time (sec)- 3
 - c. Fully open time (sec) 3
 - d. Closing time (sec)..... 150
- J. Spare Parts: The following spare parts shall be furnished:
 - 1. 1 set of all resilient seals, and discs
 - 2. 1 diaphragm (for diaphragm valves, only)

2.02 FACTORY INSPECTION, TESTING AND CORRECTION OF DEFICIENCIES

- A. Factory inspection, testing and correction of deficiencies shall be done as noted in the referenced Standard Specification and as noted herein.
- B. See Division 1 for additional requirements. Also refer to Part 1 of the Section, especially for required submission of test data to the Engineer.
- C. Factory Tests: Valves shall be factory tested with a hydrostatic test and a functional test and a test certificate shall be submitted to the ENGINEER prior to delivery of the valve.

2.03 SHOP COATING

- A. Valves and appurtenances requiring painting shall be painted and/or coated by suitable material to prevent rust on components until the time of installation and as noted in Section 09900 – Painting, if not covered herein. All items exposed to view, including in vaults shall have the exterior prepared as noted in Section 09900 – Painting.
- B. All ferrous parts of buried valves and appurtenances, except finished or greased surface, shall be given two coats of asphaltic varnish or bitumastic coating in compliance with the applicable Standard Specification, if any. After buried valves are assembled and tested, a third coat shall be applied on the exterior, unless otherwise specified.

PART 3 EXECUTION

3.01 INSTALLATION

- A. All valves and appurtenances shall be installed per the Manufacturer's instructions in the locations shown, true to alignment and rigidly supported. Any damage to the above items shall be repaired to the Engineer's satisfaction before they are installed.
- B. Install all brackets, extension rods, guides, the various types of operators and appurtenances as shown on the Drawings, or otherwise required. Before setting these items, the Contractor shall check all Drawings and figures which have a direct bearing on their location. The Contractor shall be responsible for the proper location of these valves and appurtenances during the construction of the work.
- C. All materials shall be carefully inspected for defects in construction and materials. All debris and foreign material shall be cleaned out of openings, etc. All operating mechanisms shall be operated to check their proper functioning and all nuts and bolts checked for tightness. Valves and other equipment which do not operate easily, or are otherwise defective, shall be repaired or replaced at no additional cost to the Owner.
- D. Where installation is covered by a referenced standard, installation shall be in accordance with that Standard, except as herein modified, and the Contractor shall certify such. Also note additional requirements in other parts of these Specifications.
- E. Unless otherwise noted, joints for valves and appurtenances shall be made up utilizing the same procedures as specified under the applicable type connecting pipe joint; and all valves and other items shall be installed in the proper position as recommended by the Manufacturers.
- F. Unless otherwise noted, all operational devices shall be installed with the units of the factory, as shown on the Drawings or as acceptable to the Engineer to allow accessibility to operate and maintain the item and to prevent interference with other piping, valves and appurtenances.

3.02 INSPECTION, TESTING AND CORRECTION OF DEFICIENCIES

- A. See also Division 1. Take care not to over pressure valves or appurtenances during pipe testing. If any unit proves to be defective, it shall be replaced or repaired to the satisfaction of the Engineer.
- B. Functional Test: Prior to pump station startup, all items shall be inspected for proper alignment, quiet operation, proper connection and satisfactory performance.
- C. The various pipelines in which the valves and appurtenances are to be installed are specified to be field tested. During these tests any defective valve or appurtenance shall be adjusted, removed and replaced, or otherwise made acceptable to the Engineer.
- D. Various regulating valves, strainers, or other appurtenances shall be tested to demonstrate their conformance with the specified operational capabilities, and any

deficiencies shall be corrected or the device replaced or otherwise made acceptable to the Engineer.

3.03 CLEANING

- A. All items (including valve interiors) shall be cleaned prior to installation, testing, disinfections, and final acceptance.

3.04 FIELD PAINTING

- A. Field painting is specified under Division 9. All buried metal items not otherwise coated shall receive two external coats of bitumastic paint.
- B. Field painting shall include touch ups where required.

3.05 DISINFECTION

- A. Disinfection of valves and appurtenances on all potable water lines shall be performed in accordance with City of Austin Standard Technical Specification 510 - Pipe prior to placing the valves and pipelines in service.

3.06 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 15120

PIPING SPECIALTIES

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor and materials required and installed complete and ready for operation, all appurtenances as shown on the Drawings or as specified.
- B. The appurtenances shall include, but not be limited to the following: (Note: All items listed below may not be required in this Contract).
 - 1. Yard Hydrants
 - 2. Mechanical Type Wall Seals
 - 3. Service Clamps
 - 4. Dielectric Insulating Gasket Kits for Flanges
 - 5. Dielectric Unions for Copper Tube
 - 6. Flange Bolts and Nuts
 - 7. Anti-Seize Bolting Lubricants
 - 8. Non-Insulating Flange Gasket Materials
 - 9. Sleeve ("Dresser type") Couplings
 - 10. Insulated Sleeve Couplings
 - 11. Flange Coupling Adapters
 - 12. Tie-Rod Restrained Dismantling Joints
 - 13. Depend-O-Lok Couplings
 - 14. AWWA Grooved-Joint Couplings
 - 15. Harnessing and Restraint
 - 16. Megalug Restrained Joints
 - 17. Quick Connect Couplings
 - 18. Wall and Floor Fittings
 - 19. Gauges and Accessories
 - 20. Valve Operators (Including Floor Boxes)
 - 21. Strainers
 - 22. Corporation Stops
 - 23. Appurtenances and Miscellaneous Items
 - 24. Emergency Safety Showers and Eyewash Units

1.02 SUBMITTALS

- A. Submit shop drawings in accordance with Section 01300 – Submittals and Section 15047 – Mechanical Identification. Shop drawings shall show as a minimum all details and materials of construction and dimensions.
- B. Gasket Manufacturer shall submit certificate that gasket material is suitable for the joints provided, service conditions specified herein and suitable for the field test pressure.

- C. Submit operating and maintenance instruction in compliance with Section 01730 – Operations and Maintenance Data.

1.03 REFERENCE STANDARDS

- A. American National Standards Institute (ANSI): ANSI B2.1.
- B. American Society for Testing and Materials (ASTM):
 - 1. A48 – Specification for Gray Iron Castings
 - 2. A53 – Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - 3. A126 – Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
 - 4. A183 – Specification for Carbon Steel Track Bolts and Nuts
 - 5. A193 – Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
 - 6. A194 – Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
 - 7. A197 – Specification for Cupola Malleable Iron
 - 8. A240 – Specification for Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
 - 9. A278 – Specification for Gray Iron Castings for Pressure Containing Parts for Temperatures Up to 650 degrees F
 - 10. A283 – Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
 - 11. A513 – Specification for Electric – Resistance-Welded Carbon and Alloy Steel Mechanical Tubing
 - 12. A536 – Specification for Ductile Iron Castings
 - 13. B16 – Specification for Free-Cutting Brass Rod, Brass Rod Bar and Shapes for Use in Screw Machines
 - 14. B62 – Specification for Composition Bronze or Ounce Metal Castings
 - 15. B88 – Specification for Seamless Copper Water Tube
 - 16. B584 – Specification for Copper Alloy Sand Castings for General Applications
- C. American Water Works Association (AWWA):
 - 1. C209 – Cold-Applied Tape Coatings for Steel Water Pipe, Special Sections, Connections and Fittings
 - 2. C210 – Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
 - 3. C213 – Fusion Bonded Epoxy Coating for Interior and Exterior of Steel Water Pipelines
 - 4. C219 – Bolted Sleeve Type Couplings for Plain-End Pipe
 - 5. C606 – Grooved and Shouldered Joints
- D. Federal Specifications (F.S.): MIL-C-27487

1.04 QUALITY ASSURANCE

- A. Items listed herein shall be products of Manufacturers who have a minimum of five years' experience in the manufacture of the particular equipment item to be furnished.
- B. Services of Manufacturer's Representative
 - 1. Man-hour requirements shown herein are exclusive of travel time and do not relieve the Supplier of obligation to provide sufficient service to place couplings in satisfactory operation.
 - 2. Manufacturer's factory service representative shall submit Certificate of Proper Installation of Depend-O-Lok couplings.

PART 2 PRODUCTS

2.01 GENERAL

- A. Joint, size and material (unless otherwise noted or required by the OWNER):
 - 1. Joints referred to herein shall be of the same nominal diameter as the pipe or fittings they are connected to.
 - 2. Appurtenances shall be of the same nominal diameter and same pressure rating as the pipe or fittings they are connected to.
- B. Insure that valves and appurtenances have ends/joints that are compatible with, and may be fastened to the adjoining pipe. This may mean furnishing special adaptors as required. These adaptors shall be suitable for direct bury, with proper dielectric insulation and as a minimum, if metallic non-stainless steel or galvanized, coated with two coats of Coal Tar Epoxy.
- C. Materials to be used in contact with the raw water or potable water process shall be classified as acceptable by NSF61.

2.02 YARD HYDRANTS

- A. Yard hydrants for installation on the non-potable water lines shall consist of a 3/4- inch hose connection. The hydrants shall be Woodford Model R34 Freeless Hydrant or equal. Threads shall be Austin FD Threads.

2.03 MECHANICAL TYPE WALL SEALS

- A. Mechanical type wall seals shall consist of an adjustable modular bolted, synthetic rubber and plastic sealing element as shown on the Drawings. The sealing element shall be Link-Seal LS-300-C as manufactured by Enpro Industries, or equal.

2.04 SERVICE CLAMPS

- A. Service clamps shall have malleable or ductile iron bodies which extend around the circumference of the pipe. The saddle shall be sealed against the pipe with a rubber gasket. Bodies shall be tapped for IPS. Clamps shall be of the double strap design.
- B. Service clamps shall be IPS service clamps as manufactured by Mueller Co., or equal.

2.05 DIELECTRIC INSULATING GASKET KITS FOR FLANGES

- A. Dielectric insulating flange gasket kits shall be installed when dissimilar metal pipe connects to prevent galvanic action. Flange insulation kits shall be installed where a stainless steel flange is mated with flanges constructed of bronze alloys, carbon steel alloys, or nickel alloys (Monel and Hastelloy) flanges; where process piping mates with valves and other equipment and appurtenances of dissimilar metals furnished in Division 11 and 15: where exposed piping makes a vertical transitions to buried piping; and where otherwise as shown on the Drawings.
- B. Insulating flange gaskets shall be furnished as a kit including the dielectric gasket, bolt sleeves and washers in accordance to the nominal flange size.
- C. Each dielectric insulating gasket shall be a full face isolating and sealing gasket, Type "E", 1/8" thick, epoxy-glass retainer with bolt holes cut to match matting flange drilling. The retainer shall contain a precision tapered groove to accommodate the controlled compression of a FKM (Viton) sealing element. The quad-ring seal shall be pressure energized. The epoxy-glass retainer shall have 550-volts/mil dielectric strength and a minimum 50,000 psi compressive strength.
- D. Insulating bolt-sleeves shall be manufactured of Mylar having a dielectric strength of not less than 4,000-volts/mil.
- E. Insulating washers shall be manufactured of G-10 epoxy-glass having a dielectric strength of 400 to 500-volts/mil. Insulating washers shall be installed with metallic backing washers to prevent damage to the epoxy-glass washers during bolting. The metallic washers shall be constructed of the same material as the bolts.
- F. Dielectric insulating flange gasket kits shall be:
 - 1. Linebacker manufactured by Pipeline Seal and Insulator, Houston, Texas.
 - 2. Trojan Quad Seal manufactured by Advance Products and Systems, Lafayette, Louisiana.
 - 3. Jack O-ring gaskets manufactured by Central Plastics, Shawnee, Oklahoma.

2.06 DIELECTRIC UNIONS FOR COPPER TUBE

- A. Dielectric unions for copper water tube, 1/2-inch to 2-inch diameter, shall be installed where dissimilar metal connect to prevent galvanic action. The body shall be manufactured of ASTM B16 brass and feature female NPT threads adhering to ASTM B1.20.1 and solder joints adhering to ASME B16.22. Dielectric unions shall have Nitrile (BUNA) or EPDM gaskets and be rated for 250 psi at 180° F.

<i>Connection Type</i>	<i>Copper Alloy Pipe Connection</i>	<i>Joined Material Pipe Connection</i>
Soldered	ASTM B16	ASTM A48 Cast Iron*
Soldered	ASTM B16	ASTM A197 Malleable Iron*

Threaded	ASTM B584 Bronze	ASTM A48 Cast Iron*
Threaded	ASTM B584 Bronze	ASTM A197 Malleable Iron*

*Material may be galvanized

- B. Acceptable Manufacturers:
 1. Watts, Andover, Massachusetts
 2. Wilkins, Paso Robles, California

2.07 FLANGE BOLTS AND NUTS

- A. All flange bolt lengths shall be selected by the CONTRACTOR such that three threads, as a minimum, protrude from the hex nut and washer after assembly. Flange bolts for dielectric insulating flange kits shall be fully-threaded along their length. The CONTRACTOR is cautioned that flange bolts having smooth shank segments along their length will not fit in Mylar sleeves or molded sleeve washers.
- B. All bolts, nuts, and washers in the locations listed below shall be Type 316 stainless steel as indicated below:
 1. All buried locations
 2. All submerged locations
 3. All locations subject to seasonal or occasional flooding
 4. Inside Hydraulic Structures below the top of structures
 5. Inside vaults, manholes, and junction structures
 6. All chemical handling areas
 7. Inside trenches, containment walls, and curbed areas
 8. All locations exposed to weather
 9. Locations indicated by the Contract Documents or designated by the ENGINEER to provide with stainless steel bolts.
- C. Type 316 stainless steel flange bolts shall have ASME B1.1, coarse threads, Class 2A fit, and conform to ASTM A193, Grade B8M.
- D. Flange nuts shall have ASME B1.1, coarse threads, Class 2A fit, and conform to ASTM A194 Grade 8M, Type 316 stainless steel, having square or hexagonal heavy dimensions in accordance with ASME B18.2.2. The hardness of nut shall be different than the hardness bolts to minimize galling.
- E. For locations other than listed in Paragraph 2.07.B, flange bolts shall have ASME B1.1, Class 2A threads, and be manufactured of ASTM A193, Grade B7 steel. Bolts shall conform to ASME B18.2.1.
- F. For locations other than listed in Paragraph 2.07.B, flange nuts shall have Class 2A fit, and be manufactured of ASTM A194, Grade 2H steel, having square or hex heavy dimensions in accordance with ASME B18.2.2.

2.08 ANTI-SEIZE BOLTING LUBRICANTS

- A. Flange bolts shall be installed using a nickel-seize lubricant capable of achieving the required bolt torque and sealing stress, and permitting future disassembly with minimal manual input.
- B. Anti-seize compound shall be classified as acceptable for potable water by the NSF.
- C. Acceptable Manufacturers:
 - 1. Never-Seez White Food Grade PTFE Lubricant manufactured by Bostik, Wauwatosa, Wisconsin.
 - 2. Loctite Nickel Anti-Seize Lubricant manufactured by Henkel Technologies, Rocky Hill, Connecticut.
- D. Flange bolts shall be adequately degreased of all corrosion inhibiting slush oil and excess nickel anti-seize prior to field application of prime and finish coatings.

2.09 NON-INSULATING FLANGE GASKET MATERIALS

- A. Non-insulating gaskets for all flange configurations shall be submitted in accordance with requirements specified herein. No field-cut or field modified gaskets will be allowed.
- B. Gaskets shall be full face for use with flat face flanges and ring type for use with raised face flanges. Gaskets shall be 1/8-inch thick. Blind flange gasket shall cover entire inside surface of blind flange.
- C. Gasket material shall be suitable for the joints provided, service conditions specified herein and suitable for field test pressure.
- D. Gaskets shall be classified as acceptable for potable water service by NSF 61.
- E. Gaskets shall be suitable for 250⁰ F operating temperature, unless higher temperature required on individual systems.

2.10 SLEEVE ("DRESSER TYPE") COUPLINGS

- A. Sleeve type couplings shall conform to the requirements of AWWA C219. The pressure rating of the couplings shall be at least the field test pressure it is subjected during the pressure testing of the connecting pipeline or the pressure class of the pipeline whichever is higher.
- B. The couplings shall be of a gasketed, sleeve-type with diameter to properly fit the pipe. Each coupling shall consist of cylindrical sleeve, two follower rings, two gaskets and a set of bolts and nuts.
 - 1. Sleeve: Sleeve shall be ASTM A53, ASTM A512, ASTM A513, ASTM A536 Grade 65-45-12 or carbon steel having a minimum yield strength of 30,000 psi. Sleeve shall be lined with 12 mil DFT fusion bonded epoxy compatible with potable water. Minimum sleeve length shall be five inches for pipe 12-inches and smaller, seven inches for pipe sizes 14-inches thru 24-inches, and 10-inches for pipe larger than

24-inches. Sleeve for stainless steel piping shall be fabricated of ASTM A240, Type 316 stainless steel.

2. Follower Rings: Ductile Iron ASTM A536 Grade 65-45-12, AISI C1012, AISI C1015 Steel, AISI C1018 Steel or AISI C1020 Steel. Follower rings for stainless steel pipe shall be fabricated of ASTM A240, Type 316 stainless steel.
3. Bolts and Nuts: Bolts and nuts are as specified herein.
4. Gaskets shall be of synthetic rubber suitable for service and operating conditions.
5. Finish: Fusion bonded epoxy 12 mil DFT as per AWWA C213.

C. Sleeve type couplings shall have pipe stop removed for exposed piping.

D. Acceptable Manufacturers:

1. Dresser Industries – Style 38, 138, or 253.
2. Romac Industries, Inc. – Style 400, 501, or XR501.
3. Smith-Blair – Model 411.

E. Sleeve type couplings shall be installed where shown on the Drawings and at locations where a disassembly gap is necessary to complete a piping assembly.

F. CONTRACTOR may install additional couplings other than shown on the Drawings for ease of installations without any additional cost to the OWNER.

G. In addition to those locations noted on the Drawings, sleeve couplings shall be provided on piping buried directly under a structure at the structure's expansion joints. Special treatment will be required where pipe is encased in concrete, utilizing minimum 3-inch thick styrofoam placed perpendicular to horizontal centerline coupling.

H. Joint harness shall be provided on all couplings and shall be designed for maximum test pressure to which the line will be subjected.

I. All sleeve couplings shall be thrust restraint.

2.11 INSULATED SLEEVE COUPLINGS

A. Couplings shall meet the basic requirements specified herein.

B. Insulated sleeve coupling shall be Dresser Style 39, or equivalent Smith Blair or Baker. Insulated coupling shall include boots for both pipe ends, and shall insulate each end from electrical current flow. The middle sleeve ring shall be sized to fit over the insulation boots and properly seal the connection. Restraint sleeve couplings using a thrust harness with bolts, over drill the bolt holes and install insulating sleeves and washers.

2.12 FLANGE COUPLING ADAPTERS

A. Construction:

1. Body and follower: Carbon Steel, Ductile Iron ASTM A536, Grade 65-45-12.
2. End Ring: Ductile Iron ASTM A536, Grade 65-45-12.
3. Flange: ANSI Class 125 or 250 flat face. Match class to that of piping system.
4. Bolts and nuts: As specified herein.

5. Gaskets shall be of synthetic rubber suitable for service and operating conditions.
 6. Pressure Rating: The pressure rating of the flange coupling adapters shall be at least the field test pressure it is subjected during the pressure testing of the connecting pipeline or the pressure class of the pipeline whichever is higher.
- B. Restraining or harnessing system shall be as shown on the contract Drawings for flange coupling adaptor.
- C. Factory Painting:
1. Apply fusion bonded epoxy-type protective coating system in accordance with AWWA C213, to interior and exterior of adapters. Coating for interior surface shall be NSF 61 approved for potable water. Interior and exterior of flange coupling adapters shall have Manufacturer's standard epoxy system complete with prime and finish coats minimum of 12 mils DFT.
 2. Do not paint bolts and gaskets.
 3. Coatings used on exterior of couplings which will be exposed shall be compatible with specified coating system for piping so that coupling can be painted a common color.
- D. Acceptable Manufacturers:
1. Size twelve inches and larger:
 - a. Romac Industries, Inc. – Style FC400.
 - b. Dresser Style 131.
 2. Below twelve inches:
 - a. Romac Industries, Inc. – Style FCA501.
 - b. Dresser Industries – Style 128-W.
 - c. Smith Blair – Style 912.

2.13 DEPEND-O-LOK COUPLINGS

- A. Depend-O-Lok split type bolted couplings shall meet the requirements of AWWA C219. Couplings type and size shall be as indicated on the Drawings. The pressure rating of the Depend-O-Lok couplings shall be at least the field test pressure it is subjected during the pressure testing of the connecting pipeline or the pressure class of the pipeline whichever is higher. Couplings shall pass an insulation test of 5,000 mega ohms.
- B. Construction:
1. The housing shall be one or two-piece with a double arch cross section that closes around pipe ends that are smooth for joint flexibility or expansion and contraction requirements or pipe ends with steel restraint rings affixed for pipe end restraint requirements. Depend-O-Lok ExE couplings are flexible, unrestrained pipe joints. FxE couplings are flexible, expansion joints. FxF couplings are flexible, restrained joints. Flexibility, contraction and expansion and joint restraint are as specified in the Supplier's latest literature.
 2. The housing shall be sized so that the inside diameter fits the outside diameter of the pipe. The coupling housing thickness shall be sufficient to handle the service loads.

3. Bolts or studs and nuts shall secure the closure plates and shall be as specified herein.
4. Housing and closure plates shall be carbon steel conforming to ASTM A36 or stainless steel conforming to ASTM A240 Type 316L. Sealing plates shall be stainless steel conforming to ASTM A240 Type 316L.
5. Gaskets and sealing pad bonded to the sealing plate shall be of the synthetic rubber suitable for operating condition. Gasket material properties shall meet or exceed the requirements of ASTM D2000. Gaskets shall be classified as acceptable for potable water service by NSF 61.
6. Restraint rings shall be furnished with the couplings and shall be of the same material as the coupling housings.
7. Painting: Interior and exterior of carbon steel couplings shall be coated with liquid epoxy per the requirements of AWWA C210.
8. Buried couplings shall be protected against corrosion by providing heat shrink sleeves or cold applied tape conforming to AWWA C209.

C. Acceptable Manufacturers:

1. Depend-O-Lok couplings shall be as manufactured by Victaulic Depend-O-Lok, Inc.
2. Heat Shrink Sleeves shall be as manufactured by Canusa-CPS or Raychem.

2.14 AWWA GROOVED-JOINT COUPLINGS

- A. AWWA rigid radius grooved-joint couplings for above grade ductile iron pipe, 4-inch to 36-inch diameter, shall be installed where shown on the Drawings. Grooved-joint couplings shall conform to AWWA C606 and constructed of ASTM A536, Grade 65-45-12 ductile iron.
- B. Grooved-joint couplings, 4-inch to 36-inch diameter shall be:
 1. Style 31 AWWA coupling for ductile iron pipe manufactured by Victaulic Company.
- C. Couplings for transition between ductile iron and IPS steel pipe, 4-inch to 12-inch diameter, shall be:
 1. Style 307 transition coupling manufactured by Victaulic Company.

2.15 TIE-ROD RESTRAINED DISMANTLING JOINTS

- A. Tie-rod restrained dismantling joints shall be installed where shown on the Drawings and at locations where a disassembly gap is necessary to complete a piping assembly. Dismantling joints shall be constructed of ASTM A536, Grade 65-45-12 ductile iron or ASTM A283, Grade C carbon steel. Tie rods shall be 300 series stainless steel.
- B. The pressure rating of the tie-rod restrained dismantling joints shall be at least the field test pressure it is subjected during the pressure testing of the connecting pipeline or the pressure class of the pipeline whichever is higher.
- C. Apply fusion bonded epoxy-type protective coating system in accordance with AWWA C213, to interior and exterior of dismantling joints. Coating for interior surface shall be NSF 61 approved for potable water. Interior and exterior of dismantling joints shall have

Manufacturer's standard epoxy system complete with prime and finish coats minimum of 12 mils DFT.

D. Acceptable Manufacturers:

1. Dresser Industries – Style 131
2. Smith-Blair – Model 975
3. Romac Industries – Style DJ400

2.16 HARNESSING AND RESTRAINT

- A. All flexible couplings, flanged coupling adaptors and dismantling joints shall be thrust restraint. The size and material for tie rods, clamps, plates, and hex nuts shall conform to AWWA Manual M-11 except as modified on the Drawings. Manufactured restraining clamp assemblies shall be as manufactured by Stellar Corporation or fabricated equal.
- B. Pump Manufacturer shall design thrust harness for pump suction and discharge piping in accordance with Hydraulic Institute Standards. Pump Manufacturer shall provide this information to the CONTRACTOR. The CONTRACTOR shall provide any and all restraints, exceeding those shown on the Drawings that are required by the pump Manufacturer at no additional cost to the OWNER.
- C. Restrained joints (such as welded, locking mechanical joints) shall be of the type specified with the individual type of pipe. If not specified, restrained (locking) mechanical joint pipe shall be of the manufactures standard design utilizing a locking device (ring or ears) integrally cast with the pipe.
- D. The CONTRACTOR shall be responsible for anchorage including restraint as noted in elsewhere in Division 2 and 15.

2.17 MEGALUG RESTRAINED JOINTS

- A. Joint restraint devices for ductile iron and PVC pipe shall be per the City of Austin Standard Products List. Megalug restrain devices shall be for use only with 4" – 16" ductile iron (DI) pipe or 4" – 12" PVC pipe.
- B. The devices shall have a working pressure rating same as the adjoining piping they connect to. Ratings are for water pressure and must include a minimum safety factor of 2 to 1 for all pipe sizes.
- C. Gland body, wedges and wedge actuating components shall be cast from grade 65-45-12 ductile iron material in accordance with ASTM A536.
- D. Three (3) test bars shall be incrementally poured per production shift as per Underwriter's Laboratory Specifications and ASTM A536. Testing for tensile, yield and elongation shall be performed in accordance with ASTM E8.
- E. The restraint devices shall be coated using MEGA-BOND coating system.

2.18 QUICK CONNECT COUPLINGS

- A. Couplings shall be of the cam and groove type consisting of a male adapter conforming to F.S. MIL-C-27487. Male adapters shall be designed to receive a female coupler without requiring threading, bolting, or tools. Connections shall remain tight and leak proof under pressures up to 100 psig. Each adapter shall be furnished with a dust cap complete with an 18-inch long security chain of corrosion resistant material. Couplings shall be as manufactured by Dover Corporation, Ever-tite, or equal.
- B. Adapters shall be furnished in accordance with the Drawings or as required by the installation.

2.19 WALL AND FLOOR FITTINGS

- A. Wall and floor castings, unless otherwise specified with the individual type of pipe, shall be ductile iron of the style shown on the Drawings with integral exterior water stop, standard models as manufactured by Clow, U.S. Pipe and Foundry, or equal.
- B. For plastic pipe or other pipe 2-1/2-inch diameter or less wall and floor fittings shall be ASTM A120, Schedule 40 steel sleeves with exterior steel water stop, all hot dipped galvanized after fabrication.

2.20 GAUGES AND ACCESSORIES

- A. All gauges unless otherwise noted be liquid filled and shall have 4-1/2-inch diameter face unless noted otherwise on the Drawings, with black letters on a white background and protected in their connecting piping by shut-off corporation stops or metal ball valve with level or tee handle. Gauges shall be supplied with pulsation dampers on all pressure lines. On other than potable water and air lines, gauges shall also be supplied with three-way flushing valves and diaphragm seals. Gauges shall be Class 2A with 0.5 percent accuracy over their full range and shall be as supplied by U.S. Gauge, Ashcroft, or Marsh.

2.21 VALVE OPERATORS (INCLUDING FLOOR BOXES)

- A. The valve Manufacturer shall supply and integrally mount all operators on valves at the factory. The valves and their individual operators shall be shipped as a unit.
- B. Unless otherwise noted, valves shall be manually operated; non-buried valves shall have an operating wheel, handle or lever mounted on the operator; buried valves shall have a non-rising stem with an AWWA 2-inch nut.
- C. Unless otherwise required by the OWNER, all manual operating input shafts shall turn to the left (counter-clockwise) to open the valve.
- D. Each operating device shall have cast on it the word (OPEN) and an arrow indicating the direction of operation.
- E. Provide valve position indicator for buried valves. Valve box size shall be adequate to accommodate valve position indicator.

- F. Floor boxes for operating nuts recessed in concrete floors shall be standard cast iron type, cast-in-place with fastening top by Clow or equal.
- G. Chainwheel shall be supplied for all valves larger than 3-inch in diameter whose centerline is 6 ft. or more above the floor for operation of valve. Chainwheel shall be galvanized and chain shall loop within four feet of the floor. Chainwheel diameter shall match that of the handwheel.
 - 1. Acceptable Manufacturers:
 - a. Babitt Steam Specialty, New Bedford, Massachusetts
 - b. Roto Hammer Industries, Tulsa, Oklahoma
- H. Unless otherwise noted, gear operators shall be provided for: All valves with operating shafts of larger than 8-inch nominal diameter (unless otherwise noted); for all buried valves with their operating shaft mounted horizontally (butterfly, plug, etc.); where specified and/or indicated on the Drawings; and where manual operator effort is greater than 40 ft-lbs. Gear operators shall normally be of the beveled type with output shaft perpendicular to valve shaft, having a removable hand wheel mounted on the output shaft. Gearing shall be machine-cut steel designed for smooth operation. Bearings shall be permanently lubricated, provided to take all thrusts and seals provided to contain lubricants. Housings shall exclude moisture and dirt. Manual operator input effort to the hand wheel shall be a maximum of 40 ft-lbs. to operate the valve from full open to full close, under line pressure. Gear operators shall indicate valve position and have adjustable stops.

2.22 STRAINERS

A. "Y" Type Strainers

- 1. Manual strainers furnished for pipe diameters smaller than 2 inches in diameter shall be "Y" type, capable of removing solids 0.01 inches diameter and larger. The strainer body shall be of semi-steel construction for steel pipe, and brass or bronze for copper pipe and shall conform to ASTM A278, Class 30. Strainers on plastic pipe shall be of the same material as the pipe. Strainer elements, including woven wire mesh, shall be constructed of Type 304 stainless steel.
- 2. Design of the strainer body shall be such that the clean-out plug and screw may be easily removed to permit inspection and cleaning without disassembly of inlet and outlet piping. End connections shall be ANSI screwed pipe threads.
- 3. Furnish one spare screen for each "Y" type units installed. Strainers shall be designed for a maximum operating pressure of 150 psig. They shall be as manufactured by GA Industries, Inc., or Watts Industries, Inc.

B. Manual Basket Strainers

- 1. Manual basket strainers shall be furnished for pipe 2 inches in diameter and larger, as per the Drawings. Strainer body shall be of cast iron construction. Strainer elements shall be constructed of Type 304 stainless steel. Design of the basket strainer body shall be such that the bolted lid and basket may be easily removed for inspection and cleaning without disassembly of inlet and outlet piping.
- 2. A trap with a blow-off port shall be provided for removing any material that may settle at the bottom. Strainers shall be designed for a maximum operating pressure

of 150 psig, and shall be 74-D as manufactured by GA Industries, Inc., or Watts Industries, Inc.

3. Proper blow off piping with valve shall be supplied, run to nearest drain.

C. PVC Duplex Basket Strainer

1. Provide and install PVC duplex basket strainer as shown on the Drawings.
2. Strainer shall be of PVC construction, rated for a working pressure of up to 150 PSI. Baskets shall be removable without the need for tools.
3. Strainer shall be integrally fitted with PVC ball or butterfly valves to enable diversion of flow through either of the two baskets, while the other basket is isolated for cleaning. PVC ball valves shall be provided at each basket drain.
4. Strainer shall have two Type 304 stainless steel baskets, each with 1/16" perforations, providing a minimum open area ratio of 4:1.
5. Bolt bases securely to floor using 316 stainless steel capsule anchors.
6. Strainer shall be as manufactured by Hayward Flow Control Systems, or Eaton Filtration.

2.23 CORPORATION STOPS

- A. Corporation stops shall be of bronze or brass, and shall be designed and manufactured in accordance with AWWA Standard C800, except as modified herein. Corporation stops shall have Mueller inlet threads, except that corporation stops for use with service clamps shall have IPS threads. Where corporation stops are used with plastic pipe, a brass companion flange shall be provided on the outlet of each corporation stop.

2.24 APPURTENANCES AND MISCELLANEOUS ITEMS

- A. Plugs, caps and similar accessories shall be of the same material as the pipe, and of the locking type, unless otherwise noted.
- B. Unions shall be of the same material as the pipe.
- C. Special dielectric protective tape shall be fabric reinforced petroleum tape as manufactured by Denso, Inc., or equal.

2.25 EMERGENCY SAFETY SHOWERS AND EYEWASH UNITS

- A. Furnish and install where shown on the Drawings. All assemblies shall be provided with stay-open ball valves. Provide eye wash with strainer on supply line. Units shall be complete with automatic flow control devices as required to limit emergency shower flow to 20 gpm and eye wash flow to 2.4 gpm. An emergency identification sign shall be included with each unit. Emergency safety shower and Eye Wash Assemblies shall be manufactured by Haws, Guardian, Western, Bradley, or Speakman.
- B. Interior Emergency Shower/Eye Wash Unit (ESEW-A)
 1. Furnish and install a combination emergency shower and eye wash unit where shown on the Drawings.
 2. Units shall have a 10-in cyclac plastic shower head and eye wash bowl, stay open ball valves and hand and foot control for eye wash.

3. Units shall be complete with automatic flow control devices as required to limit emergency shower flow to 20 gpm and eye wash flow to 3 gpm.
 4. Unit shall be equipped with a flow switch to provide a dry contact alarm signal when the unit is in use. The contact will be monitored by the plant SCADA system. Unit shall include strobe light and horn.
 5. Unit shall be modified to include a 8-ft hand held recoil hose assembly with bracket for spray head and equal to Haws Model #8906, Guardian Model #G1716 or Bradley Model #S-19-600
- C. Exterior Freeze-Proof Emergency Shower/Eye Wash Unit (ESEW-B)
1. Furnish and install where shown on the Drawings, a combination emergency shower and eye wash unit equipped with heating cable and insulation and designed to operate at temperatures as low as minus 40° F.
 2. Equipment shall include a ABS plastic shower head, stay-open ball valve, automatic volume control on both shower and eye wash, removable polyethylene foam insulation encased in ABS plastic jacket and a NEMA 4 enclosed thermostat. Shower flow shall be limited to 20 gpm. Eye wash shall include strainer, flow shall be 2.4 gpm.
 3. Unit shall have integral purge valve that opens when water temperature falls below 45° F. The valve shall be located opposite the water supply connection and purge approximately 6 gpm to prevent freezing in case of power failure.
 4. The unit shall be factory modified (special order) to include an additional 24-inch long section of heat trace wire exposed at piping inlet connection. Wrap heat trace wire around potable water supply from building. Insulate over heat trace and jacket outdoor exposed potable water piping.
 5. Unit shall be equal to Haws Model #8317CTFP. Other acceptable Manufacturers are Guardian and Bradley, or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Items shall be installed in strict accordance with Manufacturer's instructions in the locations shown on the Drawings. Damage to items shall be repaired to the satisfaction of the OWNER before they are installed.
- B. Install brackets, extension rods, guides, the various types of operators and appurtenances as shown on the Drawings that are in masonry floors or walls, and install concrete inserts for hangers and supports as soon as forms are erected and before concrete is poured. Before setting items, check the Drawings which have a direct bearing on their location to be responsible for the proper location of these appurtenances during construction of structures.
- C. Items shall be carefully inspected for defects in construction and materials; debris and foreign material cleaned out of openings, etc.; operating mechanisms operated to check their proper functioning, and nuts and bolts checked for tightness. Equipment which does not operate easily, or is otherwise defective, shall be repaired or replaced.

- D. Where installation is covered by a referenced Standard Specification, installation shall be in accordance with that Specification, except as herein modified.
- E. Unless otherwise noted, joints for items shall be made up utilizing the same procedures as specified under the applicable type connecting pipe joint.

3.02 INSTALLATION OF SLEEVE (DRESSER) TYPE COUPLINGS

- A. Unless otherwise required by the Manufacturer's instructions, prior to installation of sleeve-type couplings, pipe ends shall be cleaned thoroughly for a distance of at least 12 inches. Soapy water may be used as a gasket lubricant. A follower and gasket, in that order, shall be slipped over each pipe to a distance of about 6 inches from the end; the middle ring shall be placed on the already installed pipe and shall be inserted into the middle ring flange and brought to proper position in relation to the pipe already laid. The gaskets and followers shall then be pressed evenly and firmly into the middle ring flanges.
- B. After the bolts have been inserted and nuts have been made up finger tight, diametrically opposite nuts shall be progressively and uniformly tightened around the joint, by use of a torque wrench of the appropriate size and torque for the bolts.
- C. The correct torque as indicated by a torque wrench shall not exceed 75 ft-lb for 5/8-inch bolts and 90 ft-lb for 3/4-inch bolts.
- D. If a wrench other than a torque wrench is used, it should be no longer than 12 inches so that when used by the average person the above torque values shall not be exceeded.
- E. To prevent sleeve-type couplings from pulling apart under pressure, a suitable harnessing or flange clamp assembly shall be provided and installed.
- F. Note that the additional location requires sleeve couplings as specified herein.

3.03 INSTALLATION OF FLANGED COUPLINGS ADAPTERS

- A. Flanged coupling adapters shall be installed in strict accordance with the coupling Manufacturer's instructions in the locations shown on the Drawings. After the pipe is in place and bolted tight, the proper locations of holes for the anchor studs shall be determined and the pipe shall be field-filled. Holes for anchor studs shall be drilled completely through the wall pipe. Hole diameter shall not be more than 1/8-inch larger than the diameter of the stud projection.

3.04 INSTALLATION OF DEPEND-O-LOK COUPLINGS

- A. Depend-O-Lok couplings shall be installed in strict accordance with the Manufacturer's instructions in the locations shown on the Drawings. The coupling shall be assembled with bolts at the closure plates, tightened to assure snug coupling with the pipe.
- B. Manufacturer's factory trained field representative shall instruct the CONTRACTOR's field personnel for the calculation of pipe expansion and contraction based on temperature during field installation and design temperature to the joint for providing gap at the joint. The factory trained representative shall also instruct the CONTRACTOR's field

personnel for the installation of couplings. The coupling Manufacturer shall provide these services for a minimum of eight hours in the field or shall be present during installation of first two (2) couplings whichever requires longer presence in the field.

- C. Manufacturer's factory trained field representative shall submit the certificate of proper installation of couplings.

3.05 INSTALLATION OF TIE-ROD RESTRAINED DISMANTLING JOINTS

- A. Tie-rod restrained dismantling joints shall be installed in strict accordance with the Manufacturer's instructions in the locations shown on the Drawings. Tie-rods must pass through the flanges on each end of the dismantling joint. Length of all tie rods shall be same.

3.06 INSTALLATION OF GROOVED JOINTS COUPLINGS

- A. Installation of AWWA grooved joint couplings and pipe shall be in accordance with the latest version of Manual I-300 "Field Installation Handbook for AWWA Products" published by Victaulic Company.
- B. Coupling gaskets shall be installed with the Victaulic lubricant compatible with the elastomer used. Lubrication of the gasket exterior, gasket sealing lips, housings, and pipe ends shall be done prior to joining to prevent gasket pinching.
- C. Coupling nuts shall be tightened evenly by alternating sides until metal-to-metal contact occurs at the bolt pads. For angle-bolt-pad couplings, even offsets must be present at the bolt pads to obtain pipe-joint rigidity.

3.07 INSTALLATION OF WALL AND FLOOR FITTINGS

- A. Wall pipes and pipe sleeves embedded in concrete walls, floors, and slabs shall be embedded as shown. Support all pipes embedded in concrete walls, floors, and slabs with form work to prevent contact with the reinforcing steel.

3.08 INSTALLATION OF OTHER EQUIPMENT, APPURTENANCES AND MISCELLANEOUS ITEMS

- A. Unions and wall fitting shall be installed as indicated on the Drawings.
- B. Hardware and appurtenances shall be installed as required and in accordance with the Manufacturer's recommendations, as acceptable to the OWNER.
- C. Use teflon tape on screwed fittings.

3.09 FIELD TESTING

- A. Testing and correction of deficiencies shall be in accordance with Section 15000 – Special Conditions for Mechanical Work.

3.10 FIELD PAINTING

- A. Field painting is specified in Division 9. Buried metal items or those in vaults shall receive two coats of coal tar epoxy. The total DFT shall be 16 to 20 mils.

3.11 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 15140
SUPPORTS AND HANGERS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Provide all labor, materials, equipment, tools and related items required to furnish and install all pipe hangers, brackets, saddles, clamps and pipe rolls for all types of piping and duct systems. Pipe hangers and supports shall be furnished complete with all necessary inserts, bolts, nuts, threaded rods, washers and other accessories.
- B. The absence of pipe supports and details on the Drawings shall not relieve the CONTRACTOR of the responsibility for providing them. Pipe supports indicated on the Drawings are shown only to convey the intent of the design for a particular location and are not intended to represent a complete system.

1.02 SUBMITTALS

- A. Submittals shall comply with Division 1 – General Requirements and Section 15000 – Special Conditions for Mechanical Work. Submittals and shop drawings shall include complete layouts, schedules, location plans and complete total bill of materials for all pipe support systems.
- B. Complete piping drawings indicating type of hanger and/or support, location, magnitude of load transmitted to the structure and type of anchor, guide and other pipe supporting appurtenances including structural fasteners.
- C. Calculations showing size of supports using allowable stresses of material identified in MSS SP-58. All calculations shall be signed and sealed by a licensed Professional Engineer.
- D. Submit product data and details on each support.
 - 1. Product data on each support and hanger component
 - 2. Detail of each different type of support
 - 3. Location of each pipe support
 - 4. Detailed information on anti-seize compound

1.03 REFERENCE STANDARDS

- A. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS):
 - 1. SP-58 – Pipe Hangers and Supports – Materials Design and Manufacture.
 - 2. SP-69 – Pipe Hangers and Supports – Selection and Application.

1.04 QUALITY ASSURANCE

- A. Support System Design
 - 1. Engage the services of a Professional Engineer licensed in the state where the project is located. The Professional Engineer who is ordinarily engaged in the

business of pipe support system analysis, to analyze system piping and service conditions and to develop a detailed support system, specific to the piping material, pipe joints, valves and piping appurtenances proposed for use.

2. The support system shall include:
 - a. Criteria by piping system.
 - b. Summary of CONTRACTOR-selected related components including joints, class, valves, appurtenances etc., and commercial supports and especially including pipe materials.
 - c. Dead weight and dynamic analysis, including system thermal effects and pressure thrusts.
 - d. Support arrangements shall be coordinated to eliminate interference with similar systems to be installed under HVAC, Plumbing and Electrical; to account for structural expansion joints and to maintain access for both personnel and for the removal of equipment. Support systems shall not include use of monorail or bridge crane support. Nor shall they rely on the horizontal structural struts.
 - e. Commercial hardware and custom supports shall comply with the requirements herein.

B. Acceptable Manufacturers:

1. Pipe Hangers and Channel Support Systems:
 - a. Cooper B-Line Systems
 - b. Grinnell/Anvil International
 - c. Piping Technology & Products
 - d. TOLCO a brand of NIBCO
 - e. PHS Industries
 - f. Unistrut/Tyco
 - g. Powerstrut
2. Powder-Actuated Fastener Systems:
 - a. Hilti
 - b. Red Head
 - c. Masterset Fastening Systems

1.05 DESIGN CONDITIONS

- A. In certain locations, pipe supports, anchors, and expansion joints have been shown on the Drawings, but no attempt has been made to indicate every pipe support, anchor, and expansion joint. It shall be the CONTRACTOR's responsibility to design, furnish and install a complete system of pipe supports, to provide expansion joints, and to anchor all piping, as specified herein. Additional pipe supports may be required adjacent to expansion joints or couplings.
- B. Concrete and fabricated steel supports shall be as indicated on the Drawings, as specified in other Sections or, in the absence of such requirements, as permitted by the ENGINEER.

- C. All piping shall be rigidly supported and anchored so that there is no movement or visible sagging between supports with pipes full of fluid.

1.06 DELIVERY, HANDLING AND STORAGE

- A. All supports and hangers shall be crated, delivered and uncrated so as to protect against any damage.
- B. All parts shall be properly protected so that no damage or deterioration shall occur during a prolonged delay from the time of shipment until installation is completed.
- C. Finished metal surfaces not galvanized, that are not of stainless steel construction, or that are not coated, shall be grease coated, to prevent rust and corrosion.

PART 2 PRODUCTS

2.01 GENERAL

- A. Pipe hangers and supports shall be designed and constructed to meet the requirements of MSS SP-58 and SP-69.
- B. The CONTRACTOR may propose minor adjustments to the piping arrangements in order to simplify the supports, or in order to resolve minor conflicts in the Work. Such an adjustment may involve minor change to the pipe centerline elevation so that a single trapeze support may be used. Supports shall be sufficiently close together such that the sag of the pipe is within limits that will permit drainage. Where ducts interfere with the proper location of hangers, furnish and install trapeze hangers.
- C. Continuous slotted channels, channel struts and pipe clamps may be used to support multiple lines running in close proximity. Use expansion shields with bolts and horizontal drilled holes in existing concrete construction to support new piping.
- D. When two (2) or more pipes run parallel, they may be supported by trapeze hangers.
- E. Where flexible couplings are required at equipment, tank, etc., at the end opposite to the piece of equipment, tank, etc., shall be rigidly supported, to prevent transferring forces to the equipment. Fixed or restraining support shall not be installed between equipment and flexible coupling.
- F. All uninsulated non-metallic piping such as PVC, CPVC, etc., shall be protected from local stress concentrations at each support point. Protection shall be provided by galvanized steel protection shields or 1/16-inch thick neoprene sheet. Where 360 degree arc support is required, such as U bolts, protection shields or 1/16-inch thick neoprene sheet shall be provided for the entire pipe circumference. Protection shields shall have an 18 gauge minimum thickness, not less than 12-inch in length and be securely fastened to pipe with stainless steel metal strap not less than 1/2-inch wide.
- G. All insulated piping shall be furnished with a rigid foam insulating saddle at each pipe support location.

- H. Where pipe hangers and supports come in contact with copper piping provide protection from galvanic corrosion by: wrapping pipe with 1/16-inch thick neoprene sheet material and galvanized protection shield; isolators or copper plated or PVC coated hangers and supports.
- I. Provide neoprene isolators between the pipe and support components where dissimilar metals come in contact.
- J. All vertical risers shall be supported by riser clamps or supports at each floor and every five feet. All vertical pipes passing through pipe sleeves shall be secured using a pipe collar.
- K. Supports shall be provided at changes in direction. Changes in the direction shall be supported as close as practical to the fitting to avoid introducing excessive torsional stresses into the system. No piping shall be supported from other piping or from metal stairs, ladders and walkways unless specifically directed by the OWNER's Representative.
- L. Whenever expansion and contraction of piping is expected, a sufficient number of expansion loops or joints shall be provided, together with the necessary rolling or sliding supports, anchors, guides, pivots, and restraints permitting the piping to expand and contract freely in directions away from the anchored points. All components shall be structurally suitable to withstand all loads imposed. Effects of thermal expansion and contraction of the pipe shall be accounted for in the pipe support selection and installation.

2.02 MATERIALS

- A. All hangers, brackets, clamps, hardware, etc. shall be Type 316 stainless steel unless noted otherwise. Do not use perforated strap hangers.
- B. All pipe support assemblies including framing other than indicated below shall be galvanized steel.
 - 1. All submerged piping, as well as piping, conduits and equipment in hydraulic structures within 24-inches of water level shall be supported with support assemblies including framing, hardware, and anchors, constructed of Type 316 stainless steel.
 - 2. All piping in chemical and corrosive areas shall be supported with support assemblies including framing, hardware, and anchors constructed of Type 316 stainless steel or FRP.
 - 3. All outdoor piping shall be supported with support assemblies including framing, hardware, and anchors constructed of Type 316 stainless steel.
- C. Metal Framing:
 - 1. Provide channels fabricated from not less than 12-gauge thick, 1-5/8" wide and not less than 1-5/8" deep.
 - 2. Use Type 316 stainless steel channels and components in all areas unless noted otherwise on the Drawings.

- D. All anchor bolts shall be stainless steel as specified in Section 05051 – Anchor Bolts, Expansion Anchors, and Concrete Inserts. Space anchor bolts a maximum of 24-inches on center, with not less than two bolts per piece of framing.
- E. Fiberglass Reinforced Pipe (FRP): Wear protection pad shall be used at each pipe support. It shall be designed in accordance with AWWA Manual M45. The wear protection pad material shall be as per the Manufacturer's recommendation and based on the application. It shall be from one of the following:
 - 1. Support Saddles manufactured by NOV Fiber Glass System
 - 2. Blank or Wear Saddles manufactured by Ameron International
 - 3. Wear pads manufactured by Conley
- F. All individually suspended horizontal pipes in the building shall be supported by stainless steel rods sized as follows:

<i>Pipe Size (in Inches)</i>	<i>Rod Size (in Inches)</i>
2 and smaller	3/8
2-1/2 - 3-1/2	1/2
4 - 5	5/8
6	3/4
8 through 12	7/8
14 through 18	1
20 through 24	1-1/4

2.03 TYPE

- A. Pipe hangers and supports shall be selected from one of the types shown on Figure 1 of MSS-58 and MSS-69 or as indicated on the Drawing, where applicable. Plastic pipe support spacing shall be as specified herein and in accordance with the plastic pipe Manufacturer's recommendations whichever is smaller.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Pipe Support Spacing:
 - 1. General:
 - a. Pipe hanger and support installation shall comply with the requirements of MSS SP-69, MSS SP-89 and this Section. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
 - b. Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems. Field assembled channel system shall be installed according to Manufacturer's written instructions.

- c. The pipe supports spacing shall not exceed the maximum span scheduled in Paragraph 3.01.A.1.g unless indicated otherwise.
- d. Provide at least one support for each length of pipe, at each change of direction, and at each valve or equipment.
- e. Locate pipe supports as shown in Table 3 of MSS-69 for piping not scheduled below or shown otherwise.
- f. Provide continuous support as required for small tubing to properly support the tubing along the pipe run and at connections to equipment.
- g. Pipe Support Schedule:
 - (i) Steel, Stainless Steel and Cast-Iron Pipe Support Schedule:

<i>PIPE SIZES - IN</i>	<i>* MAXIMUM SPAN (FT)</i>	<i>ROD SIZE - IN</i>
2 and less	5	3/8
2½ thru 3½	10	½
4 thru 5	10	5/8
6	10	¾
8 thru 12	15	7/8

- (ii) Copper Pipe Support Schedule:

<i>PIPE SIZES - IN</i>	<i>* MAXIMUM SPAN (FT)</i>	<i>ROD SIZE - IN</i>
2½ and less	5	1/2
3 thru 6	10	¾
8 and greater	15	7/8

- (iii) PVC, ABS Pipe Support Schedule:

<i>PIPE SIZES - IN</i>	<i>* MAXIMUM SPAN (FT)</i>	<i>ROD SIZE - IN</i>
1-1/4 and less	3	3/8
1-1/2 thru 3	4	1/2
4 and greater	5	3/4

*Maximum fluid temperature of 120° F.

Support spacing apply to continuous spans with no concentrated load.

B. Application:

1. Support piping approximately 1-1/2-inches out from the face of walls and at least three inches below ceilings.

2. Concrete inserts or L-shaped anchor bolts shall be used to support piping from new cast-in-place concrete. Epoxy or Expansion (as specified in Section 05051 – Anchor Bolts) anchors shall be used to fasten supports to existing concrete and masonry.
 3. Design loads for inserts, brackets, clamps, and other support items shall not exceed the Manufacturer's recommended loads.
 4. Pipe supports shall be manufactured for the size and type of pipe to which they are applied. Threaded rods shall be sufficient threading to permit the maximum adjustment available in the support item.
 5. Anchorage shall be provided to resist thrust due to temperature changes, changes in diameter or direction, or dead ending. Anchors shall be located as required to force expansion and contraction movement to occur at expansion joints, loops or elbows, and as required to prevent excessive bending stresses and opening of mechanical couplings. Anchorage for temperature changes shall be centered between elbows and mechanical joints used as expansion joints.
 6. Pipe guides shall be provided adjacent to bellows type expansion joints. Guides shall be placed on both sides of expansion joints except where anchors are adjacent to the joints. Guides will not be required when mechanical couplings are permitted as expansion joints. Pipe supports shall allow adequate movement; pipe guides shall not be used for support. Pipe guides shall be installed as recommended by the Manufacturer.
 7. Concentrated loads (valves, flanges, etc.) shall be supported directly or supported immediately adjacent to the load. Valves shall be braced against operating torque.
- C. Adjustment: All hangers shall be adjustable. Wall hangers shall have slotted bolt holes. Ceiling hangers shall have turnbuckles. Floor supports shall have extended anchor bolts such that the support can be wedged to proper elevation and grouted. Provide a minimum of one inch of grout.
- D. Pipe Rack: Pipe supported on pipe rack shall be supported on channels. Clamp pipes on the channel support by pipe clamps.
- E. Touch Up:
1. Touch up all scratches or cuts on steel components with an approved zinc chromate or 90 percent zinc paint.
 2. Use a PVC compound on PVC-coated components.
- 3.02 INSULATED PIPE
- A. Insulated pipe shall have protective saddles where supported. Insulation shall pass through the supports. Size supports for the full outside diameter of the insulation.
- 3.03 PLASTIC OR FIBERGLASS PIPE
- A. Plastic or fiberglass pipe shall have cradles and rubber pads to distribute the load over a length of at least six inches, or more if indicated on the Drawings, at all supports.

3.04 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 15204

ELECTRIC VALVE OPERATORS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required, and install and test, complete and ready for operation, the electric valve and gate operators as shown on the Drawings and as specified.
- B. The operators shall be provided by the respective valve and gate MANUFACTURER, but shall conform to this Section. The intent of this requirement is to give the valve or gate supplies the authority and responsibility to provide a coordinated valve/gate and operator.
- C. All operators powered with 208 Volts AC/3Φ/60Hz and provided under this Section shall be the products of a single MANUFACTURER, regardless of the sources of the valves and gates which they control. Further, to the extent possible, all operators provided hereunder shall be of the same model series and type. Coordinate between suppliers as required.
- D. All operators shall be equipped as required by the appropriate control schematic in the electrical drawings.

1.02 RELATED WORK

- A. Painting in addition to the requirements in this Section, is specified in Division 9 – Finishes.
- B. Mechanical piping, valves, pipe hangers and supports are specified in their respective sections of the Contract Documents.
- C. Electrical Work, in addition to the requirements of this section, is specified in Division 16 – Electrical.
- D. Motors, in addition to the requirements of this Section, are described in Division 16 - Electrical.

1.03 SUBMITTALS

- A. Shop Drawings and Product Data:
 - 1. Comply with the general requirements of Section 01300 – Submittals and the supplemental requirements herein.
 - 2. MANUFACTURER's literature, illustrations, specifications, detailed drawings, data and descriptive literature on all valves and appurtenances.
 - 3. Submittal data for each valve, gates, operator, and actuator.
 - 4. Deviations from the Contract Documents.
 - 5. Engineering data including dimensions, materials, size and weight.

6. Fabrication, assembly, installation and wiring diagrams.
7. Submit the following information for electric operator:
 - a. Utilization voltage and number of phases.
 - b. Maximum current.
 - c. Horsepower.
 - d. Time to close.
 - e. Wiring diagram.
 - f. Type of gearing and lubrication.
 - g. Type of declutching mechanism.
 - h. Torque delivered to valve shaft.
 - i. Make and model.
8. If catalog bulletins are used to communicate above information, mark out inapplicable information.

B. Design Data

1. Submit MANUFACTURER's certified data showing operator characteristics of torque, speed, power requirements and consumption, options provided, operational flexibility characteristics to be provided, and total unit weight. This information shall be prepared specifically for each operator size and type proposed. Catalog sheets showing general information and options available will not be acceptable.

C. Operation and Maintenance Data: Submit MANUFACTURER's operating and maintenance instruction in compliance with Section 01730 – Operation and Maintenance Data for equipment furnished under this Section.

D. Shop Test:

1. Test motor operated valves before shipment to ensure that the mechanisms can close the valves in the specified time limit, and for proper seating.
2. Hydrostatic tests shall be performed, when required by the valve and gate specifications included herein.

1.04 REFERENCE STANDARDS

AWWA C542 – Electric Motor Actuators for Valves and Slide Gates.

1.05 QUALITY ASSURANCE

A. Qualifications

1. The equipment covered by these Specifications is intended to be standard valve and gate operating equipment of proven ability as manufactured by reputable company having extensive experience in the production of such equipment. Units specified herein shall be furnished by a single MANUFACTURER. The equipment furnished shall be designed, constructed and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed as shown on the Drawings.

2. The associated valve and gate MANUFACTURER shall be fully responsible for the design, arrangement, and operation of all connected components, to ensure that neither harmful nor damaging nor unexpected actions result under and condition within the specified operating ranges.
3. Operators shall be as manufactured by
 - a. Rotork; or
 - b. Limitorque
4. The operators shall be complete with all required controls. The valve and gate MANUFACTURER shall be responsible for the furnishing and performance of the complete valve units, including the operators.

B. Services of MANUFACTURER's Representative

1. A factory representative, who has complete knowledge of proper operation and maintenance of the operators, and is skilled in teaching same, shall be provided to instruct representative of the OWNER and the OWNER'S REPRESENTATIVE on proper operation and maintenance. Training shall include both field and classroom instruction, including the use of such model or prototype equipment as is necessary to provide adequate "hands-on" training. Factory representative shall inspect installation of the valve operators and conduct a test run of the equipment as specified in Item 5.
2. Services of factory representative shall be coordinated with those of the valve and gate MANUFACTURER's representative.
3. Services shall be provided as required to place equipment in satisfactory operation, but at least one 8-hour day shall be provided (exclusive of travel time).
4. Actuator/Controls Start-up Personnel
 - a. The Supplier of the valve and gate actuators and related controls shall provide a factory-trained technician to supervise, calibration, and start-up as required. On completion of start-up, a certificate of installation shall be provided by the valve and gate actuator supplier indicating proper installation and start-up procedures have been followed. This document certifying the installation shall be included as part of the final operation and maintenance manuals. The Supplier of valve actuators and related controls shall provide a factory-trained technician for operation and maintenance training of OWNER's personnel.
 - b. CONTRACTOR and/or MANUFACTURER shall video tape training sessions and provide copies to the Owner.

1.06 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS

- A. All equipment and materials specified herein are intended to be standard for use in controlling the flow of water and air.
- B. The MANUFACTURER of the equipment specified herein shall be required to review and satisfy all relevant requirements of other Sections of the Contract Documents and the requirements of the Contract Drawings. The CONTRACTOR, MANUFACTURER, supplier, fabricator and/or Subcontractors furnishings and/or installing equipment, services and specialties associated with this Section shall fully coordinate their efforts

to avoid potential claims that are based on failure to review relevant Contract Documents, including the Contract Drawings.

1.07 DELIVERY, HANDLING AND STORAGE

- A. All parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of shipment until installation is completed and the unit and equipment are ready for operation.
- B. All equipment and parts must be properly protected against any damage during on-site storage. All compartment heaters shall be powered at all times, whether the operator is in storage or installed but not yet in operation.
- C. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the OWNER'S REPRESENTATIVE.
- D. Finished iron or steel surfaces not painted shall be properly protected to prevent rust and corrosion.

1.08 MAINTENANCE/SPARE PARTS

- A. Furnish one set of all special tools required for the proper servicing of all equipment supplied under these Specifications, clearly identified and packed in a suitable steel tool chest with a lock. Furnish the MANUFACTURER's standard set of spare parts for each operator size and type provided, including at least the following:
 - 1. One set of gaskets, O-ring, grommets and other sealing devices for each operator furnished.
 - 2. A supply of all required lubricants, sufficient for one (1) year of normal operation.
- B. In addition to the above inventory to be maintained, the equipment MANUFACTURER shall submit evidence that he can deliver a replacement for any part furnished within three working days via surface transport.

1.09 EXTENDED WARRANTY

- A. The manufacturer shall provide an all-inclusive warranty starting at the date of successful startup and Owner acceptance. Warranty shall be two (2) years for the operators. The warranty shall include normal wear and tear of parts. All materials, equipment, and workmanship shall be free from defects in material or workmanship.

PART 2 PRODUCTS

2.01 MATERIALS

- A. General
 - 1. Operators are distinguished in the following Articles according to the power source used to operate the included motor, 208-Volt. The use of a MANUFACTURER's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.

2. Like items of materials/equipment shall be the end products of one MANUFACTURER in order to provide standardization for appearance, operation, maintenance, spare parts, and MANUFACTURER' service.
3. Equipment weighing over 100 pounds shall be provided with lifting lugs.
4. Stainless steel nameplates with the name of the MANUFACTURER, the rated capacity, speed, and all other pertinent data shall be furnished and attached to the operators.
5. Inaccessible actuators shall be controlled from a wall-mounted, operating control panel located within its proximity. Coordinate with OWNER to verify exact location of control panel.

B. 208-Volt Electric Valve and Gate Operators

1. Electric motor-driven valve and gate operators shall include the motor operator, unit gearing, limit switch gearing, limit switches, torque switches, fully machined drive sleeve, declutch lever, galvanized steel stem cover (if applicable), local control station, control power transformer, reversing starter, condensation heaters, incoming non-fused disconnect with one "a" and "b" auxiliary contact, and auxiliary handwheel. The operators shall be fully self-contained.
2. All valve and gate operators shall conform in all respects to AWWA C542, except as herein modified.
3. The valves and gates to be actuated by operators covered in this Specification Section are shown in the Drawings.
4. All electric valve and gate operators shall conform to the following:
 - a. Supply voltage: 208-Volt, 3-Phase, 60 Hertz.
 - b. NEMA 4, water-tight enclosure construction.
 - c. 120-Volt motor and control compartment heaters required.
 - d. Position indicators are required.
 - e. Stem protectors with position indication are required for all gate installations.
 - f. Electrical controls to be integral with the operator and shall included at least two full extra sets of reversing-starter contacts, and a minimum of two full extra sets of limit-switch contacts, each adjustable to fully open, fully closed and any intermediate position. The valve control panel will be provided by the OWNER but shall be installed and connected by the CONTRACTOR.
 - g. Auto-phase correction shall be incorporated into the integral controls so that any of the possible wiring connections of the three-phase power leads by site technicians will lead to correct output rotation to open and close the valves.
 - h. A monitor relay shall be provided so that if the actuator fails to respond to a command, it can be noted by viewing fault indicators on the actuator, as well as a signal to the control room, that a problem exists. The remote monitor relay circuit shall include a field selectable normally open or normally closed contact for remote fault indication. On the actuator, LED's will indicate if the actuator is failing to respond due to a tripped thermal motor overload, a torque-switch trip or a loss of phase.
5. Motors shall be specifically designed for valve and gate operator service and shall be high torque, totally enclosed, non-ventilated construction, with motor leads brought into the limit switch compartment without having external piping or

conduit box. The motor shall be capable of seating and unseating the valve and gate against maximum differential pressure when voltage to the motor terminals is ten percent above or below nominal. Minimum rated torque capability of each operator shall be 2.0 times the maximum required to seat, unseat, and rigidly hold the valve or gate open under operating conditions. The motor shall be pre-lubricated and all bearings shall be of the anti-friction roller-bearing type. All bearings shall be of the anti-friction type. All motors shall be rated for 15 minute continuous duty during any 30-minute period.

6. The unit gearing shall consist of generated helical or spur gears of heat treated steel and worm gearing. The worm shall be carbonized and hardened alloy steel with the threads ground after heat treating or rolled and heat treated. The worm gear shall be alloy bronze accurately cut with a hobbing machine. All unit gearing shall be fully lubricated. The gear train shall be sealed. Ball and roller bearings shall be used throughout.
7. Limit switches and associated gearing shall be an integral part of all valve and gate operators. The limit switch gearing shall be of the intermittent type, totally enclosed in its own gear case. Limit switches shall be adjustable rotor type capable of being adjusted to trip at any point between fully seated and fully unseated positions. Each valve operator shall be provided with a minimum of four rotor-type geared limit switches. Each rotor shall be equipped with four silver inlay type contacts. Each contact shall be field selectable for either normally open or normally closed operation. Limit switches shall be geared to the driving mechanism at all times whether in motor or manual operation. Switches shall require no regular maintenance. Torque switches shall be wired in series.
8. Each valve operator shall be equipped with a double torque switch. The torque switch shall be adjustable and shall be responsive to load encountered in either direction of travel. It shall operate during the complete cycle to protect the valve should excessive load be met by obstructions in either direction of travel. Travel and thrusts shall be independent of wear. The double torque switch (or two torque switches) shall be wired in parallel in the open or close branch circuits, and shall operate properly regardless of phase rotation. The valve supplier shall furnish motorized valve operator controls as indicated on the electrical drawings, complete with pilot lights, auxiliary control relays, push buttons, LOCAL/OFF/REMOTE switches, thermal magnetic circuit breaker, etc. Torque switches shall be tested and set at the factory prior to shipment.
9. A permanently mounted handcrank or handwheel shall be provided for manual operation, the handcrank/wheel shall not rotate during electric operation, but shall be responsive to manual operation at all times except when being electrically operated. Handwheel shall be a minimum of 18" diameter and a maximum of 24" diameter. The motor shall not rotate during hand operation, nor shall a seized motor prevent manual operation. When in manual operating position, the unit shall remain in this position until the motor is next energized at which time the operator shall automatically return to electric operation and shall remain in motor position until handwheel operation is next desired. This movement from motor to handwheel operation shall be accomplished by a positive declutching lever which shall disengage the motor and motor gearing mechanically, not electrically. It shall not be possible to place the unit in manual operation when the motor is

running. Rim pull on the manual handwheel or handcrank shall not exceed 40 pounds.

10. Condensation heaters shall be provided to protect the limit switch, motor, and control compartments.
11. Each operator shall be capable of accepting discrete remote control signals from remote contact closures. Terminals shall be provided to facilitate termination of all field control and status wiring.
12. A terminal strip shall be provided in the switch compartment. Controls and switch compartments shall be shop-wired to terminal strip complete and ready for field installation. All wires to the terminal strip shall be identified.
13. In those cases where full-stroke times are not provided; sluice gate, slide gate, weir gate, and gate valves shall move at a rate of one-foot per minute; ball, plug, and butterfly valves shall move at a rate of 90° in two minutes.
14. A schematic wiring diagram shall be attached and protected from the environment for maintenance use.

C. Surface Preparation and Shop Coating

1. All surfaces, other than stainless steel or fully UV-resistant plastics, shall be shop coated in accordance with Section 09900 – Painting.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Installation of the operators shall be in strict compliance with the MANUFACTURER's instructions and recommendations in the locations shown on the Drawings. Installation shall include furnishing the required oil and grease for initial operation. The grades of oil and grease shall be in compliance with the MANUFACTURER's recommendations.
- B. Anchor bolts shall be set by the CONTRACTOR in compliance with the MANUFACTURER's recommendations.
- C. Field tests shall not be conducted until such time that the entire installation is complete and ready for testing.
- D. A certificate from the equipment MANUFACTURER stating that the installation of this equipment is satisfactory, that the equipment is ready for operation, and that the operating personnel have been suitably instructed in the operation, lubrication and care of each unit shall be submitted.
- E. Assembly of Actuators to New Valves
 1. For valves having direct-mounted actuators, except those furnished with extension shafts, torque tubes, or floorstands, the valve and actuator shall be assembled and performance tested in accordance with Section 5.1.1 of AWWA C504.

3.02 FIELD TESTING

- A. The valves, gates, and appurtenances and the various pipelines in which these are to be installed shall be field tested by the CONTRACTOR. During these tests any defective valve, gate, or appurtenance shall be adjusted, removed and replaced, or otherwise made acceptable to the OWNER and OWNER's Representative by the CONTRACTOR.
- B. Various regulating valves, or other appurtenances, shall be tested by CONTRACTOR to demonstrate their conformance with the specified operational capabilities and any deficiencies. Any deficiency shall be corrected or the device replaced or otherwise made acceptable to the CONTRACTOR and OWNER's Representative.
- C. Operators shall be full-load field tested in conjunction with respective valve or gate testing.
- D. MANUFACTURER's field representative shall conduct tests in presence of OWNER.

3.03 FIELD PAINTING

Field painting shall be in accordance with the requirements of Section 09900 – Painting.

3.01 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 15256

INSULATION AND HEAT TRACING

PART 1 GENERAL

1.01 SCOPE

The work to be performed under this Section of the Contract Documents consists of furnishing and installing insulation and heat tape on piping and equipment as required herein, unless otherwise indicated specifically on individual plans and appropriate Sections of Contract Documents.

1.02 SUBMITTALS

A. Product Data and Shop Drawings.

1. Submit product data and shop drawings on insulation, heat tracing materials, etc., in accordance with Division 1 – General Requirements and Section 15000 – Special Conditions for Mechanical Work.

1.03 REFERENCE STANDARDS

A. The system shall be suitable for the specified industrial conditions, and shall be designed and installed in accordance with the latest applicable codes and standards. Pertinent standards are:

1. American National Standards Institute (ANSI)
2. Institute of Electrical and Electronics Engineers (IEEE)
3. American Society for Testing and Materials (ASTM)
4. National Fire Protection Association (NFPA)
5. National Electric Code (NEC)
6. Factory Mutual (FM)
7. Underwriters Laboratories (UL)
8. National Electrical Manufacturers Association (NEMA)
9. Occupational Safety and Health Administration (OSHA)

B. Furnish copies of the necessary approvals for the heat tracing system and verify that the approvals are current.

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 DESIGN REQUIREMENTS

A. Provide a heat tracing system capable of maintaining the specified temperature during the extreme of ambient temperature.

B. Design Parameters

1. Voltage Available..... 120 Volts 1 Phase
2. Wind Velocity..... 160 mph

3. Low Ambient Temperature..... -20°F
4. Maintain Temperature 65 degrees F
5. Piping and equipment lists and insulation types and thicknesses are found in Division 15 and on the Drawings.

- C. Heat losses shall be calculated using the Manufacturer's standard procedure in conjunction with the insulation requirements and equipment schedules. The design heat output of the tracing shall include a 10 percent factor of safety. The CONTRACTOR is encouraged to suggest changes in insulation thickness to optimize total system economy.
- D. Heating cables shall be run parallel to the pipe only. Spiral wrapping of the heat cables around the pipes shall not be permitted.
- E. Comply with all requirements of Division 16 – Electrical.
- F. Systems that are PLC controlled shall not be allowed.

PART 2 PRODUCTS

2.01 GENERAL

- A. Engage the services of qualified insulation personnel to furnish and install all the insulation required for the piping specified hereinafter. Heat tracing shall be of constant wattage.
- B. All surfaces to be insulated shall be clean and dry before applying the insulation. All sections of molded pipe covering shall be firmly butted together. Where coverings are used, they shall lap the adjoining section of insulation by at least 3 inches. Where insulation terminates, it shall be neatly beveled and finished. No insulation shall be applied until the pipe has been pressure tested and found tight. Piping flexible connections, flanges and unions shall not be covered. All materials used shall be fire retardant or nonflammable.
- C. Where vapor barriers are required, the vapor barrier shall be on the outside. Extreme care shall be taken that the vapor barrier is unbroken. Joints, etc., shall all be sealed. Where insulation with a vapor barrier terminates, it shall be sealed off with the vapor barrier being continuous to the surface being insulated. Ends shall not be left raw.
- D. Aluminum bands shall be applied on the piping insulation. The bands shall be applied three to a section of pipe insulation. Fittings, valves, etc., shall have bands on each side. Apply bands at each end of pipe support.
- E. Where supports are on the outside of the insulation, use a section of Foam glass or rigid cork insulation at support locations and provide No. 14 gage stainless steel sleeves, 12 inches long on pipe sizes up to 12 inches and 18 inches long on larger pipe sizes to protect the insulation. The sleeves shall be half cylinders with the edges hemmed to prevent cutting the insulation.

- F. All materials used shall have a flame spread rating of not more than 25 without evidence of continued progressive combustion, and with a smoke developed rating not higher than 50. Shop drawing submittals shall show this information.
- G. Weather exposed insulation shall be protected with 0.010 inches minimum aluminum jacket including vapor barrier liner of laminated asphalt Kraft paper.

2.02 FREEZE PROTECTION

- A. Insulation:
 - 1. Unless otherwise indicated in the specific requirements and/or on the plans, all piping, fittings, valves and related items smaller than 12 inches exposed outdoors in yard in an unheated space subject to freezing shall be heat trace and insulated.
 - 2. Buried yard piping need not be insulated.
 - 3. Piping capable of draining automatically need not be insulated.
 - 4. All insulation of pipes shall run to a point 12 inches below ground surface.
- B. Heat Tracing: Electric heat tapes shall be provided inside the insulation for freeze protection on all piping receiving insulation subject to freezing. The rate and quantity of insulation shall be specified hereinafter.
- C. Schedule: Unless otherwise specified or shown elsewhere in the contract documents, the following schedule of insulation and heat tape application shall be used:

Insulation Schedule for Piping Subject to Freezing.

Nominal Pipe Size (in)**	Insulation Thickness (in)	Insulation "K"*	Heat Tape Application Rate (Minimum) Watts/Linear Feet
1/2	2	0.3	1.0
3/4	2	0.3	1.2
1	2	0.3	1.2
1-1/2	2	0.3	1.5
2	2	0.3	1.8
2-1/2	2	0.3	1.9
3	2	0.3	1.9
4	2	0.3	2.7
6	2	0.3	2.7
8	2	0.3	2.7
10	2	0.3	2.7
12	2	0.3	2.7

* "K" - Thermal conductivity of insulation in BTUH per square foot per degree Fahrenheit, per inch.

** Insulation and heat tape required for a pipe size not shown on the schedule shall be the same as the next larger pipe size shown on this schedule.

PART 3 EXECUTION

3.01 HEAT TRACING

- A. Pipelines or equipment subject to freezing shall be heat traced as indicated on "Insulation Schedule," paragraph 2.02. Furnish and install on such pipeline or equipment an electric heat tracing system consisting of a flat, flexible, low heat-density electrical heating strip of self-limiting parallel-circuit construction consisting of an inner core of conductive material between two parallel copper bus strips with a polyolefin outer jacket. The strip shall be cut-to-length in field and installed on pipelines and equipment as required. The electrical insulation of the heater strip shall be rated at 185 F minimum temperature exposure and shall be suitable for 115, 208 volts as indicated on plans or as available. The heat tracing system shall be complete with all necessary power connections, end seals, adjustable thermostats and electric traced signed per Manufacturer's installation instructions.
- B. Acceptable Manufacturers (or approved equivalent):
 - 1. Raychem (Chemelex)
 - 2. Nelson Electronic
 - 3. Chromalox
 - 4. Thermon Manufacturing Company

3.02 INSULATION

- A. The insulation specified herein shall be furnished and installed by qualified insulation personnel whose principal business is the application and installation of thermal materials on piping systems. All material shall be manufactured by one of the listed approved Manufacturer's instructions, except where these instructions conflict with the Contract Documents hereinafter stated, in which case the Contract Documents shall govern. All work shall be performed in a neat workmanlike manner and all adhesives, bands and other fastening materials and devices shall be supplied as required to properly install the insulation materials being furnished.
- B. Acceptable Manufacturers (or approved equivalent):
 - 1. Armstrong Co.
 - 2. CertainTeed
 - 3. Owens-Corning Fiberglass
 - 4. Pittsburg Plate Glass Co.
 - 5. Pittsburg – Corning

3.03 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 15500

HVAC – GENERAL PROVISIONS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This Section specifies the general requirements of the HVAC work to be performed and described in other Division 15 sections, and shall not void any of the requirements specified under the General Conditions or General Requirements.
- B. Furnish all labor, materials, equipment, services and incidentals required and install and test the reconfigured HVAC and odor exhaust system as specified and shown on the Contract Drawings.
- C. The requirements specified herein shall be modified only if specified otherwise for particular application in other Divisions.
- D. Work to be included under the "Scope of Work" of each HVAC Specification Section shall include all labor, material, equipment, tools and services necessary to furnish, deliver, unload, install, test and place in satisfactory operation the equipment, services and systems as called for under each HVAC Section including any incidental work not shown, or not specified but which can reasonably be inferred as belonging to the various systems and necessary in good practice to provide complete and fully operational systems.
- E. This HVAC specification is incomplete without the information contained on the Drawings and in the Equipment Schedules.
- F. Refer to Section 15891 for the FRP ductwork and accessories.
- G. Description of the work included in each Section is not intended to in any way limit the above broad statement, but is intended as a more specific mention of the most important items included therein.
- H. Design Conditions:
 - 1. Outdoor Design Conditions
 - a. The following outside design conditions will be used, based on climate data at Austin/Mueller Municipal Airport, as documented in the 2013 ASHRAE Fundamentals Handbook:
 - b. Summer (0.4%): 99.8°F Dry-bulb, 74.5°F Wet-bulb
 - c. Winter (99.6%): 26.6°F Dry-bulb
 - 2. Indoor Design Conditions
 - a. Refer to individual HVAC drawings and sequences of operation for indoor design conditions and setpoints.
 - 3. Capacity of equipment is indicated at actual operating conditions, unless otherwise noted. Size equipment to perform as indicated at site elevation and scheduled conditions.
- I. Job Conditions

1. Examine Contract Documents to determine how other work will affect execution of mechanical work.
2. Determine and verify locations and arrangement of existing utilities, systems and equipment, and become familiar with existing conditions.

1.02 RELATED WORK

- A. The following work related to, but not covered under the HVAC work, will be done under other related Divisions as listed below.
 1. Cutting and patching, except for items specified herein.
 2. Temporary heating, electric power and lighting.
 3. Concrete work, except for furnishing of required anchor bolts, sleeves and templates, which shall be furnished with equipment.
 4. Structural steel and miscellaneous metal, except for supplementary steel required for hangers, equipment supports, anchors and guides, which shall be furnished with equipment.
 5. Flashing and counter-flashing, except for items specified herein.
 6. Painting, except for factory finished equipment, shop painting and identification labeling.
 7. Refer to other divisions for electrical requirements.
 8. Electrical field power and interlock wiring, except for field wiring for automatic temperature HVAC controls as specified and as shown on the HVAC Drawings.
 9. Motor starters and disconnects, except for those furnished as an integral part of equipment supplied under this Division, shall be provided under Electrical.
- B. Related Documents:
 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUBMITTALS

- A. Shop Drawings - Submit to the Owner's Designated Representative, in accordance with Division 01, all shop drawings and product data specified in this Section and in each individual HVAC Specification Section. All information should be provided at one time for each specification section. Incomplete submittals will be rejected. Submittals shall include the following minimum information:
 1. Catalog Cutsheets – Provide for each equipment unit and accessory. Indicate options from cutsheets with arrows, or equivalent. Indicating options with a highlighter marker is unacceptable, as it does not transmit during the copying process. Indicate specification number and equipment tag number on all cutsheets. As a minimum, provide information for the following:
 - a. Catalog data on vibration isolators, including materials of construction, operating efficiency and layout diagrams that locate the isolators on the equipment by model number.
 - b. Catalog data on bearings and confirmation of bearing life for the service specified.
 - c. Information on coatings as specified in the coating section.

2. Drawings – Provide description of the materials of construction, location and size of exhaust air openings and clearance requirements for maintenance access, furnished specialties and accessories.
 3. Accessories – A list of all accessories and options to be furnished shall be included on each submittal.
 4. Spare Parts List – Provide manufacturer's recommended spare parts list.
 5. Detail mounting and securing structure.
 6. Warranty Information
 7. Provide nameplate data and arrangement for approval by Owner's Designated Representative.
 8. Equipment and materials shall be in strict accordance with the Specification requirements. Fully explain and itemize any exceptions to, or deviations from the Contract Specifications with references to the individual specification sections.
 9. Where corrosion resistance is required, provide conformation of material suitability for the specified service.
 10. All submittals shall contain a statement that all specification Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.
- B. In the event the vendor and/or manufacturer starts procurement and/or fabrication prior to receipt of approved shop drawings, then vendor/manufacturer does so at their own risk.
- C. In general, corrections or comments or lack thereof, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the Drawings and Specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner. Items resubmitted by Contractor shall specifically reference comments made on submittal review documents. Failure to do so may prolong submittal review process and cause additional incurred costs.

1.04 REFERENCE STANDARDS

- A. The latest published issue of Standards or Recommendations of the following listed Societies, Associations or Institutes are part of this Section. These shall be considered as minimum requirements. Specific requirements of this Section and/or Drawings shall have precedence. In case of conflict between published requirements, the Engineer shall determine which is to be followed.
- B. Abbreviation and the title of Federal, State and industry standards, technical societies, associations and institutes and other organizations used are as follows:
1. AABC – Associated Air Balance Council
 2. ACGIH – American Conference of Governmental Industrial Hygienists
 3. ADC – Air Diffusion Council

4. ABMA – American Bearing Manufacturers Association
5. AMCA – Air Movement and Control Association
6. ANSI – American National Standards Institute
7. ASHRAE – American Society of Heating, Refrigerating and Air Conditioning Engineers
8. ASME – American Society of Mechanical Engineers
9. ASTM – American Society for Testing and Materials
10. FM – Factory Mutual Engineering and Research Corp.
11. IEEE – Institute of Electrical and Electronics Engineers
12. NIST – National Institute of Standards and Technology
13. NEBB – National Environmental Balancing Bureau
14. NEC – National Electrical Code
15. NEMA – National Electrical Manufacturers Association
16. NFPA – National Fire Protection Association
17. OSHA – Occupational Safety and Health Administration
18. SMACNA – Sheet Metal and Air Conditioning Contractors National Association
19. UL – Underwriters Laboratories
20. State and city building, plumbing and mechanical codes.
21. Authorities having jurisdiction.

- C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

- A. The Contractor shall be fully responsible for the proper execution and performance of the work described herein. It shall be their responsibility to inspect all installation conditions and bring to the attention of the Owner's Designated Representative any conditions which may affect their work adversely. They shall report to the Owner's Designated Representative prior to commencing any portion of this work, any conditions unsuitable for the installation of their portion of the work.
- B. Attention is called to the necessity for elimination of transmission of excess and nuisance vibration and noise from mechanical equipment to building structures. All equipment, therefore, shall be carefully selected and installed to meet this condition and isolators, sound deadening material and water hammer arrestors shall be provided where required.
- C. Inspection by the Owner's Designated Representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.
- D. Use all new materials unless otherwise specified. Materials and equipment shall be free from all defects and imperfections that might affect the serviceability of the finished product. No used equipment or materials will be allowed.
- E. The Owner's Designated Representative reserves the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

- F. Use of asbestos or material containing asbestos shall be strictly prohibited.
- G. Guarantee that all equipment meets the design and performance requirements specified, and alter and/or replace, at no cost to the Owner any piece of equipment which fails to meet these requirements.
- H. If, during the performance of the work, the Contractor finds a conflict, error or discrepancy between or among one or more of the Sections or between or among one or more Sections and the Drawings, Contractor shall address said conflict, error or discrepancy in accordance with Section 00700.

1.06 DRAWINGS

- A. The Drawings are essentially diagrammatic, although all work shown on the Drawings is approximately shown to scale. Figured dimensions and detailed drawings shall be followed in every case. Size and routing of ductwork are shown, but it is not intended to show every offset, crossover, transition or fitting nor every structural difficulty that may be encountered. To carry out the true intent and purpose of the Drawings, the Contractor shall provide all necessary parts for a final installed system which conforms to the structure, avoids obstructions and provides required clearances and passageways. The Contractor shall be responsible to coordinate the system installation and routing with the work of all other trades.
- B. Do not change sizes indicated on the Drawings without written approval of the Engineer.
- C. When significant changes in equipment locations, devices and distribution systems are required, obtain approval of the Engineer before making changes.
- D. The absence of duct and pipe supports and details on the Drawings shall not relieve the Contractor of the responsibility for providing them.
- E. The location of all equipment and ductwork shall be considered as approximate only and the right is reserved by the Engineer to change at any time, before the work is installed, the position of such equipment and ductwork to meet structural conditions and to provide proper headroom clearance or for other sufficient causes and such changes shall be made without additional expense to the Owner.
- F. For locations of building elements, refer to dimensioned architectural/structural drawings.
- G. Field measurements take precedence over dimensioned drawings.

1.07 CODES, LOCAL CODE AMENDMENTS AND ORDINANCES

- A. Comply with all the laws, ordinances, codes, rules and regulations of the State, local or other authorities having jurisdiction over any of the work specified herein. All such laws, ordinances, codes, rules and regulations governing this work shall be a part of the Specifications. Where the requirements of the Specifications and Drawings are more stringent than the codes, ordinances, etc., the Contract Documents shall take precedence.
- B. Obtain all required permits and pay all legal fees for the same and in general take complete charge and responsibility for all legal requirements pertaining to this Section of the work.

- C. If any work is performed and subsequent changes are necessary to conform to the regulations, such change shall be made as part of this work at no additional cost to the Owner.

1.08 DELIVERY, STORAGE AND HANDLING

- A. Refer to general requirements under Division 01 and the following specific requirements.
- B. All materials and equipment shall be inspected for size, quality and quantity against approved shop drawings upon delivery.
- C. Deliver equipment and materials to the site in the manufacturer's original, unopened containers and packaging. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.
- D. All equipment and materials shipped that are exposed such as on a flatbed truck shall be protected during transit. The equipment and materials shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.
- E. For short term storage at the Project site, all equipment and materials shall be stored in a covered dry location off of the ground and stored in a temperature-controlled location.
- F. Provide covering and shielding for equipment and materials to protect from damage.
- G. Repair, restore and replace damaged items.
- H. Protect equipment and materials and finishes during handling and installation to prevent damage.

1.09 COORDINATION

- A. The Drawings indicate the extent and general arrangement of the systems. If any departures from the Drawings or specifications are deemed necessary, details of such departures and the reasons therefore shall be submitted as soon as practical for review. No such departures shall be made without the prior written concurrence of the Engineer.
- B. Refer to the Structural and Architectural Drawings which indicate the type of construction in which the work shall be installed. Locations shown on the HVAC Drawings shall be checked against the general and detailed drawings of the construction proper. All measurements must be taken at the building.
- C. The Contractor shall coordinate the location and placement of all concrete inserts and welding attachments with the structural engineer.
- D. The Contractor shall assume full responsibility for coordination of the HVAC systems with the work of all trades, including; scheduling, and verification that all structures, ducts and the mounting of equipment are compatible.
- E. It shall be the responsibility of the subcontractor to have employed a competent coordinator of mechanical systems and as such to provide all coordination of drawings or sketches as may be required or deemed necessary by the Engineer to obtain the required ceiling heights and eliminate conflicts with all ducts, electrical, process mechanical and installations of all other trades.

1.10 ENGINEERING SERVICES

- A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.
- B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.
- C. Provide one original and three copies of the licensed professional engineer's certification.

1.11 WARRANTY

- A. Warrant all material and workmanship included herein. Warranty shall include parts & labor for a period of 1 year from date of final acceptance by Owner. The Contractor shall be responsible for all cost incurred in furnishing and installing the replacement equipment.
- B. Refer to Division 01 for general warranty requirements.

1.12 DEFINITIONS

- A. Particular terminology used under this Division is defined as follows:
 - 1. Fan Unit – Any unit or assembly containing a fan, motor and drive.
 - 2. Temperature Controller – Any device which is used to modulate the automatic temperature control system by a change in temperature at the location of the controller.
 - 3. Explosion Proof – Any equipment or device, which is called to be explosion proof, shall be certified as explosion proof as a complete unit.
 - 4. Readily Accessible – Shall mean that the unit shall be accessible without the need for ladders, harness or other device. Basically the unit shall be accessible at operator level. It shall also mean that no equipment, piping, or other systems shall need to be removed or dismantled to access the unit.
 - 5. Easily Accessible - Shall mean that the unit shall be accessible without the need for removing or dismantling any equipment, piping, or other systems; however it may require the use of a ladder or harness to reach the unit.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Due to the corrosive nature at the plant, special attention shall be made to materials of construction called out in each specification section and on the equipment schedules in the Drawings. Where not called out in each individual specification section or on the Drawings, all material for equipment, ductwork, dampers, linkages, supports, hardware, etc. specified under this Division shall be constructed of corrosion resistant materials –

FRP, aluminum or type 316L stainless steel. Uncoated steel, galvanized steel or painted steel shall not be acceptable unless specifically indicated otherwise in the Drawings or equipment specifications.

2.02 FLAME AND SMOKE RATINGS

- A. All materials, including adhesives, surface coatings, sealers, assemblies of several materials, insulation, jacketing, finish, etc., shall have flame spread ratings not over 25 (fire resistive) and smoke development ratings not over 50 and fuel contributed rating not over 50, as established by tests conducted in accordance with the Federal Standard 00136B, National Bureau of Standards Radiant Energy Fire Test and the National Fire Code of the NFPA.
- B. These requirements shall apply to all circumstances whether the materials are field applied or have been applied by a manufacturer in his/her shop, or elsewhere, prior to delivery to the project for installation.

2.03 LABELS

- A. Provide labeling and tags for ductwork, piping and equipment.

PART 3 EXECUTION

3.01 INSTALLATION

- A. All products shall be installed according to the applicable manufacturer's recommendations, the details shown on the Drawings and as specified herein and in other related Sections in this Division.
- B. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.
- C. Install all ductwork and trim in accordance with the manufacturer's printed instructions and install rigid, plumb and true to line, with all parts in perfect working order.
- D. The Contractor shall not install any equipment or materials until the Owner and Owner's Designated Representative(s) have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.
- E. Provide necessary anchoring devices and supports.
 - 1. Use structural supports suitable for equipment, or as indicated.
 - 2. Check loadings and dimensions of equipment with shop drawings.
 - 3. Do not cut, or weld to, building structural members.
 - 4. Provide equipment supports even though not detailed on mechanical, architectural and structural drawings.
- F. Verify that equipment will fit support layouts indicated. Where substitute equipment is used, revise indicated supports to fit.
- G. Arrange for necessary openings to allow entry of equipment. Where equipment cannot be installed as structure is being erected, provide and arrange for building in of boxes, sleeves or other devices to allow later installation or purchase equipment in manufactured sections to allow move-in and reassembly.

- H. Install ductwork to permit easy access for normal maintenance.
 - 1. Maintain easy access to motors, drives, electrical panels and process equipment and arrange conduit, ducts and related work to facilitate maintenance and to meet or exceed NEC required clearances.
 - 2. Relocate items which interfere with access or NEC required clearances.

3.02 TESTS AND INSPECTIONS

- A. General – Test and inspect all systems and put into satisfactory operation prior to final acceptance by Owner. Test the work as required by the Owner's Designated Representative during the progress of the work to demonstrate the strength, durability and fitness of the installation. Furnish all instruments, ladders, lubricants, test equipment and personnel required for the tests; including manufacturer's representatives for testing and startup of all supplied equipment. Balancing and testing shall be performed as specified herein and by related Sections in this Division. All testing shall be performed, witnessed, and signed off in the presence of the Owner's Designated Representative.

Final Tests – Tests of all systems shall be carried out as required by the Owner's Designated Representative prior to final acceptance of the systems for the purpose of demonstrating satisfactory functional and operating efficiency as well as adjustment. All failure modes, safeties, alarms, and interlocks shall be included in the functional testing. During this period, the setting of all automatic controls shall be checked and sufficient measurements taken to ensure that conditions are correct and that capacities are adequate to meet the specified requirements. Provide competent personnel to conduct all tests. Systems will not be considered complete until all tests have been concluded to the satisfaction of the Owner's Designated Representative and all other parties having jurisdiction. In event of leakage or defects, tests must be repeated until all faults are corrected. All tests shall be performed in the presence of the Owner's Designated Representative. The general operating tests shall be performed under as near design conditions as possible. Four signed and witnessed copies of records of all tests, measurements, settings of throttling devices and nameplate data shall be submitted to the Owner's Designated Representative.

- B. Test and Inspection Reports – Contractor shall submit certified and witnessed test reports, verifying that equipment is operating per the contract documents and design conditions. Where the individual specification sections require factory-trained representatives to make inspections and/or assist with testing. The name and contact information of said individuals shall be in the test and inspection reports. Four copies of records of all tests, measurements, settings of throttling devices and nameplate data shall be submitted to the Owner's Designated Representative.
- C. Contractor shall demonstrate satisfactory performance of all equipment and systems for a minimum period of 5 working days prior to final acceptance by Owner.

3.03 PROTECTION

- A. Materials, fixtures and equipment shall be properly protected at all times and all pipe openings shall be temporarily capped or plugged so as to keep dirt and debris out. Keep plug or cap in place until final connections are made.
- B. Protect nameplates on all equipment from damage and paint.

3.04 CLEANING

- A. All equipment, fan wheels, motors, ductwork and piping shall be left in a thoroughly cleaned condition. Refer to related specification sections and Division 01 for additional information.

3.05 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 15891

HVAC – NON-METAL DUCTWORK AND ACCESSORIES

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish, fabricate and install all fiberglass reinforced plastic (FRP) ductwork including fittings, accessories, dampers, hangers and any incidental work or components required and provide complete air system as shown on the Drawings and as specified herein.
- B. Design, furnish and install seismic restraints and braces for all ductwork and accessories. Refer to Division 01 for seismic design requirements.
- C. In general, ductwork shall consist of any passageway made of FRP substantially air-tight, used for the conveying of air, gas or materials. Included are fittings, transitions, bracing, fasteners, sealers, supports and accessories such as access panels, access doors, turning vanes and manual air balancing dampers. All ductwork shall be of size and material as specified herein and as shown on the Contract Drawings. All duct sizes indicated on the Drawings are clear, inside dimensions.
- D. Any change in duct sizes, offsets, transitions and fittings required to accommodate job conditions shall be submitted to the Engineer for approval.
- E. All ductwork, piping, and equipment shown on the Drawings is intended to be approximately correct to scale, but figured dimensions and detailed drawings of the actual equipment furnished shall be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of ductwork and piping are shown, but it is not the intent to show every offset or fitting, nor every hanger or support, or structural difficulty that may be encountered. To carry out the intent and purpose of the Drawings all necessary parts to make a complete working system ready for use shall be furnished without extra charge. The Contractor shall be responsible to coordinate the system installation and routing with the work of all trades.
- F. Design, furnish and install the odor exhaust stack as indicated herein and as shown on the drawings.

1.02 RELATED WORK

- A. Section 15990 — HVAC Testing, Adjusting and Balancing.

1.03 SUBMITTALS

- A. Submit, in accordance with Division 1, the following:
 - 1. Ductwork shop drawings shall include typical details of transitions, elbows, fittings, duct drains, test ports, accessory items such as access panels or access doors, turning vanes, volume control dampers, volume extractors, supports and hangers, joining methods, bracing and material gauges. Drawings shall include materials of construction information, dimensions and installation details. Drawings of general layouts of individual systems shall be submitted, scale shall be 1/4-in = 1-ft-0-in minimum.

- B. The following additional data shall be submitted.
1. Manufacturer's qualification and experience data, specifications and installation instructions, factory and field quality control procedures catalog data, brochures, descriptive matter, illustrations, diagrams and color charts of ductwork to be selected.
 2. Specific handling and storage requirements for ductwork, joint kits and resin systems.
 3. Shop drawings shall include design criteria, i.e. allowable air temperature range and duct pressure limit ranges for duct material to be provided.
 4. Shop drawings shall list thickness, description and composition of each layer of FRP duct material.
 5. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.
 6. Sample coupons of laminate not less than 1-ft square. Provide sample laminate coupons for each method of manufacture and for both round and rectangular duct manufacturing methods.
 7. Resin system data, including chemical environment service test data, case history data of similar installations (with contact addresses), resin pot life and time versus temperature data required for complete resin cure for laminate thicknesses actually proposed.
 8. Submit design calculations signed and sealed by a professional engineer and fabrication procedures for record purposes only. Also submit a letter certifying that the laminates fabricated with the proposed resin system will give satisfactory performance under the specified service conditions and stating the service conditions for which certification is provided and indicating compliance with specified pressure and vacuum design criteria.
 9. Submit construction details for flexible connectors, expansion joints, elbows, transitions, junctions and flanged fittings including dimensioned laminate cross sections and flange fabrication and assembly details.
 10. Submit results of factory readings taken with "Barcol Hardness Impressor" and provide procedure to field check for complete cure of resin.
 11. Certified service tables for the resins being used and the expected contaminants showing satisfactory services for the required design conditions.
 12. Detailed instructions for field joining of the ductwork to include quality control procedures.
 13. Submit shop test reports for fiberglass reinforced plastic (FRP) dampers, including leakage, pressure drop and maximum pressure data in accordance with AMCA 500. Provide data for all damper sizes.
- C. In general, corrections or comments or lack thereof, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 REFERENCE STANDARDS

- A. American Society for Testing and Materials (ASTM)
 - 1. ASTM D3982 - Standard Specification for Contact Molded Fiberglass Duct and Hoods.
 - 2. ASTM D2996..... - Standard Specification for Filament Wound Fiberglass Pipe
 - 3. ASTM C581 - Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service.
 - 4. ASTM D4385 - Clarifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products.
 - 5. ASTM E84 - Surface Burning Characteristics of Building Materials.
- B. National Fire Protection Association (NFPA)
 - 1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilation Systems.
 - 2. NFPA 91 - Standard for Exhaust Systems for Air Conveying of Materials.
 - 3. NFPA 252 - Standard Methods of Fire Tests of Door Assemblies.
- C. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
- D. American National Standards Institute (ANSI)
 - 1. ANSI RTP-1 - Reinforced Thermoset Plastic Corrosion Resistant Equipment.
- E. Air Movement and Control Association International, Inc. (AMCA)
 - 1. AMCA 500 - Test Methods for Louvers, Dampers and Shutters.
- F. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

- A. All FRP duct and fittings, except for accessories such as dampers, flexible connections, turning vanes, etc., shall be from a single manufacturer experienced in the fabrication and installation of systems similar to those specified.
- B. All materials shall be supplied by a manufacturer experienced in the fabrication of materials similar to those specified. Design and engineering shall be performed by personnel regularly employed by the manufacturer who are experienced in the design of FRP systems similar to those specified.
- C. Engineering analysis and design of the ductwork systems, including interior and exterior hangers and supports, and analysis and design of components to allow for system thermal expansion and contraction shall be provided using either or both of the following
 - 1. Performed by personnel regularly employed by the fabricator, who are experienced in the design of FRP systems similar in size and complexity to those specified and shown on the Drawings.
 - 2. Performed by an independent engineering firm according to the applicable regulations for professional engineers, to include signing, sealing and dating documents.

- D. The manufacturer shall provide factory trained personnel for training of installers and for supervision and inspection of the installation. The use of local sales representatives for this service is not acceptable.
- E. Corrosion resistance data shall be based on ASTM C581.
- F. Inspection by the Owner's Designated Representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.
- G. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Refer to 15500 — HVAC General Provisions and the following additional requirements.
- B. Equipment, material and spare parts are to be shipped complete except where partial disassembly is required by transportation regulations or for protection of components. No ductwork or components shall be shipped prior to complete resin cure.
- C. Inspection of the duct and components will be made by the Owner's Designated Representative after delivery. Materials shall be subject to rejection at any time on account of failure to meet any of the specified requirements. Material rejected after delivery shall be marked for identification and shall be immediately removed from the job site.
- D. Store all fiberglass joint kits, and resins to provide protection from fire, precipitation, dust, and salt, and to maintain product storage temperatures within the limits established by the manufacturer's storage and handling requirements. Observe all manufacturer's storage and handling requirements and recommendations. All resin system components, not consumed by the end of their recommended shelf life, shall be removed from the jobsite.

1.07 COORDINATION

- A. The drawings indicate the extent and general arrangement of the systems. If any departures from the drawings or specifications are deemed necessary, details of such departures and the reasons therefore shall be submitted as soon as practical for review. No such departures shall be made without the prior written concurrence of the Engineer.
- B. The Contractor shall coordinate the location and placement of all concrete inserts and welding attachments with the structural engineer.
- C. The Contractor shall assume full responsibility for coordination of the HVAC systems, including; scheduling, and verification that all structures, ducts, piping and the mounting of equipment are compatible.
- D. The Contractor shall not install any equipment or materials until the Owner's Designated Representative has approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

1.08 STANDARDS OF CONSTRUCTION AND INSTALLATION

- A. All ductwork construction and installation details shown on the Drawings and specified herein are based on acceptable methods of construction and installation and are intended to define the quality of construction and installation to be furnished. Alternate details may be submitted for approval together with a reason for requesting the use of an alternate.

1.09 ENGINEERING SERVICES

- A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.
- B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

PART 2 PRODUCTS

2.01 MATERIAL

- A. Design Conditions
 - 1. Temperature: minus 10 to 125 degrees F
 - 2. Internal Pressure: 15-in H₂O w.g. positive; 15-in H₂O w.g. negative
 - 3. Design duct and supports for all material weight, wind, snow, and seismic loads.
 - 4. Flow medium and velocity: air at 2500 fpm
 - 5. Wall thickness: Minimum structural thickness shall be 0.1-inches (0.153-inch with corrosion liner).
- B. Corrosive Environment
 - 1. The following chemical/moisture/temperature conditions are expected to be in the air stream or surrounding area. The resins used shall be suitable for all of the following:
 - H₂S (hydrogen sulfide) - up to 20ppm
 - Water Vapor - up to 100% RH
 - Temperature Range: 0 deg. F to 120 deg. F typical
- C. Ductwork Design Standards
 - 1. Ductwork structural analysis and design calculations shall be performed in accordance with the procedures specified in ANSI/ASME RTP-1 latest edition.
 - 2. Where reference is made to compliance with ASTM D3982 requirements, those requirements shall be considered the minimum acceptable criteria and may be used

only when the calculations performed according to ANSI/ASME RTP-1 procedures demonstrate that the ASTM D3982 requirements meet the specified design criteria.

- D. Design of ductwork shall include all loads applied to the ductwork, in addition to the load of the duct. These loads include but are not limited to wind, snow, seismic and internal dirt or liquid buildup.

2.02 FIBERGLASS REINFORCED PLASTIC (FRP) DUCTWORK

- A. FRP ductwork shall be of contact molded (hand layup) or filament wound construction, or a combination of these methods, to meet the design criteria.
- B. FRP ductwork structural layers and exterior shall have a flame spread rating of 25 or less and a smoke developed rating of not more than 50 in accordance with NFPA 91.
- C. Laminates shall consist of a 20 mil (finished thickness) minimum chemical resistant interior liner with an apertured synthetic surface veil embedded in a resin rich surface. The internal liner that is in contact with the contaminated exhaust air stream shall be constructed of materials resistant to the chemicals stated above. The corrosion barrier shall be a minimum of 100 mils thick and include not less than two layers of 1-1/2 oz mat with 25 percent glass and 75 percent resin content. Corrosion barrier shall be specifically layered up as a corrosion barrier and formed separately from the materials and procedures of the structural layer(s). The structural layer shall be of sufficient thickness to meet the minimum thickness requirements specified. The structural layer shall be fabricated by either filament wound or hand laid-up techniques to the dimensional thickness and strength required by the ASTM Standards. The outer surface shall be relatively smooth with no exposed glass fiber ends. Resins used for the intermediate structural layer shall be selected for their strength characteristics. The exterior surface layer shall be resin rich "A" veil not less than 20 mils thick. Outside finish of ductwork installed outdoors shall be a pigmented, paraffinated gel coat with an ultra violet inhibitor. The inner surface shall be free of cracks and crazing with a smooth finish and with an average of not over two pits per square foot, providing the pits are less than 1/8-in in diameter and not over 1/32-in deep and are covered with sufficient resin to avoid exposure of inner surface fabric. Some waviness is permissible as long as the surface is smooth and free of pits.
- D. The exposed external surface of all FRP ductwork installed inside the building shall carry a flame spread rating of 25 or less and a smoke contribution of 50 or less. All indoor ductwork shall be identified by a finished appearance in the white color spectrum to be readily distinguishable from ductwork used outdoors.
- E. The exposed external surface of all FRP ductwork installed outdoors, whether on grade or on roof, shall be provided with protection against ultraviolet degradation and weather erosion. The duct shall carry the flame spread rating of 25 or less and a smoke contribution rating in excess of 1,000. External duct protection shall be provided by an ultraviolet stabilizer added to the final coat or resin that also incorporates paraffinated wax curing elements and color pigment. An alternative system to polyurethane paint with color pigments may be used if approved by the Owner's Designated Representative.
- F. Resins used in the laminate shall be premium corrosion resistant and fire retardant vinylester resins and shall contain 3 percent NYACOL as a fire retardant.

- G. Fittings and Joints: All fittings such as elbows, laterals, tees and reducers shall be of the same resin as and equal or superior in strength to the adjacent duct section and shall have the same internal dimensions as the adjacent duct. Non-flanged duct joints shall be butt wrapped or bell and spigot joints. Bell and spigot joints shall be sealed with a standard butt joint overlay as per ASTM D3982. The interior opening between the bell and spigot shall be sealed with a resin paste so that no glass fibers are exposed and all voids are filled. Field cut duct ends and exposed glass fibers shall be resin coated prior to joint assembly to maintain a continuous interior corrosion barrier. Coat all exterior surfaces of joints with a paraffinated resin-rich gel coat with UV inhibitors.
- H. Total width of overlay for butt-wrap joints shall be not less than 6-in for diameters from 6-in up to and including 30-in, 36-in and larger shall be not less than 10-in.
- I. Round Standard Elbows
1. Standard elbow centerline radius shall be equal to 1-1/2 times the diameter unless noted otherwise on the contract documents.
 2. Standard elbows up to 24-in diameter shall be smooth radius molded elbows. Standard elbows 30-in diameter and greater may be mitered sections as specified below.
 3. 0 to 45 degree elbows shall contain a minimum of three gores. 46 to 90 degree elbows shall have a minimum of five gores.
- J. Rectangular Fittings
1. Fittings shall be factory manufactured to meet the specified design criteria and in accordance with approved submittals. Factory install reinforcing ribs as required to meet the specified deflection requirements and to provide a system free from pulsing, warpage, sagging and undue vibration.
 2. Provide smooth radius in all rectangular elbows. Rectangular elbow turning vanes shall be of FRP construction, solid or double wall construction with an airfoil shaped profile.
- K. Reinforcing
1. Round duct reinforcing when required shall be factory installed with spacing between reinforcing located to avoid all hangers and support saddles.
 2. Rectangular duct and fitting reinforcing when required shall be factory located and installed to avoid duct hangers, support saddles, bracing, branch take-offs and entries, and plenum connections. Routine field cutting and field relocation of factory installed reinforcing is not acceptable.
- L. Tolerances
1. Out-of-roundness of duct shall be limited to plus or minus 1/8-in or plus or minus 1 percent of duct inside diameter, whichever is greater for duct sizes 6-in diameter and greater.
 2. Rectangular duct tolerances shall be 3/16-in for duct diameter up to 18-in and plus or minus 1 percent for dimensions of over 18-in.
 3. All unflanged duct shall be square on the ends in relation to the pipe axis and plus or minus 1/8-in up to and including 24-in diameter and plus or minus 3/16-in for all diameters greater than 24-in.
 4. Fittings

- a. The tolerance on angles of all fittings shall be plus or minus 1 degree, up to and including 24-in diameter and plus or minus 1/2 degree for 30-in diameter and above.
- 5. Flanges
 - a. Flange faces shall be perpendicular to the axis of the duct within 1/2 degree.
 - b. Flange faces shall be flat to within plus or minus 1/32-in, up to and including 18-in diameter and flat within plus or minus 1/16-in for 20-in diameter and larger.
 - c. Provide custom filler pieces as required to mate flanges squarely.
- M. Calculations for wall thickness determination shall be based on the structural fiberglass reinforced wall only. Long term deflection shall not exceed 1 percent of duct diameter or duct width for rectangular ducts. Round and rectangular FRP ductwork shall be designed using a safety factor of 10 to 1 for pressure and 5 to 1 for vacuum service. Round duct shall be designed by manufacturer to resist specified loadings but in no case shall FRP duct be less than 2-Filament wound layers. Rectangular duct may be reinforced with angles or tees as required to meet the required pressure/vacuum service.
- N. All connections to expansion joints, butterfly dampers or other equipment shall be flanged. Gaskets shall be Chlorobutyl material for H₂S and H₂S₀₄. Flanges shall be hand laid up to thickness specified in ASTM D3982 except that minimum thickness shall be 3/4-in. Each flange face shall be ground flat, and a new 100 mil corrosion barrier shall be applied. The flange shall be anchored to a waxed table to ensure the flatness tolerance outlined above. The face shall be textured for use with full face chlorobutyl gaskets, 1/8-in minimum thickness. Flange drilling shall be as per ASTM D3982. All bolt holes shall be back spot faced for a washer seat. All flange bolts shall be torqued to values as recommended by manufacturer. All flanges shall be factory drilled (two hole or one hole) and coordinated with mating flanges except at connections to flexible connectors or equipment.
- O. Fasteners: Furnish all bolts, nuts, washers and other fasteners required. Material of metallic fasteners shall be Type 316 stainless steel.
- P. Provide duct saddles at each duct support location to minimize stresses imparted directly onto duct. Where impractical to provide saddles, such as at elbows, fittings, etc., provide at each duct support location an extra reinforcing layer of FRP, either the same thickness as the FRP duct or 1/4-inch thickness, whichever is greater, to minimize stresses imparted directly onto duct, minimum 1/3 circumference and minimum 6-inches past edge of support. Refer to Drawings for additional information.
- Q. At all duct low points or where ductwork cannot be sloped to drain internal condensate to process areas, provide 1-in minimum threaded CPVC nipple with two-CPVC ball valve duct drains. Provide 6" minimum length clear PVC pipe between ball valves in the bottom of all main, branch and riser ducts to allow removal of condensate (top valve normally open, bottom valve normally closed). Contractor shall locate drains as indicated on the drawings. Contractor shall also provide additional duct drains not indicated on drawings at all low points and other areas deemed necessary for collecting condensate based on the actual routing of ductwork in the field. Duct drains with ball valve shall be so arranged such that there is sufficient clearance below drain outlet for placement of bucket by plant personnel for manual removal of condensate.

- R. Duct sizes shown on the Drawings represent the nominal free area required for that service.
- S. Manufacturer: Field-fabricated ductwork shall not be acceptable. Ductwork shall be factory manufactured from one of the following manufacturers. Provide products of one of the following:
 - 1. Belco Mfg. Inc.
 - 2. Ershigs Incorporated.
 - 3. Or equal.

2.03 FLEXIBLE CONNECTORS

- A. Flexible connectors shall be airtight, watertight, fire retardant, weather and UV resistant and resistant to hydrogen sulfide. Furnish flexible connectors at each inlet and outlet of fan and in the duct runs where required for expansion, contraction and movement and/or where indicated on the Drawings. Flexible connections shall be integral flange molded arch type units constructed of material same as gasket material specified above. The flexible connections shall be weather and UV resistant, suitable for outdoor service and temperature ranges from minus 10 up to 125 degrees F, and pressures to positive 5 psig and negative 1 psig. Flex connectors shall be flanged and constructed of materials of similar or greater chemical resistance as duct system. The flexible connections shall be designed to minimize the transmission of vibration from the fans to the ductwork at the suction and discharge connections. Expansion or contraction flexible connections shall be designed to allow 1-in movement. Working length or "live" length shall be as designed by the manufacturer to allow up to 1-in of movement. Ends shall be flanged, with flanges matching duct connection flanges. Specially fabricated split Type 316 stainless steel retaining back-up bars shall be supplied to prevent damage to the hypalon flanges when Type 316 stainless steel bolts are tightened. Fabric must comply with Underwriters Laboratories Standard UL214 and NFPA Bulletin 102.
- B. Furnish flexible connectors in the duct runs where required for expansion, contraction and movement and/or where indicated on the Drawings. Flexible connections shall be integral flange molded arch type units constructed of Chlorobutyl rubber 1/4-in thick, suitable for corrosive service, including hydrogen sulfide. Flex connectors shall be flanged and constructed of materials of similar chemical resistance as duct system. The flexible connections shall be designed to minimize the transmission of vibration from the fans to the ductwork at the suction and discharge connections. Expansion or contraction flexible connections shall be designed to allow 1-in movement. Working length or "live" length shall be as designed by the manufacturer to allow up to 1-in of movement. Ends shall be flanged, with flanges matching duct connection flanges. Corners on rectangular expansion joints shall be molded and free of patches or splices. The flexible connections shall be suitable for outdoor service and temperature ranges from minus 10 up to 125 degrees F, and pressure to 5 psig. Specially fabricated split Type 316 stainless steel retaining back-up bars shall be supplied to prevent damage to the rubber flanges when Type 316 stainless steel bolts are tightened.
- C. Where the construction of the flexible connections or vibration isolator results in a cross sectional area of the connection which is less than 90 percent of the adjacent ductwork, the size of the connection shall be increased to provide a cross sectional area equal to or greater than 90 percent of the adjacent duct.

- D. Ductwork spacing and alignment for flexible connections shall be aligned to the tolerances of the flexible connection manufacturer, or plus/minus 1/4-in whichever is less. Bolts shall be torqued to the manufacturer's recommendations. Do not over tighten.
- E. Where flexible connections are used as expansion joints, the manufacturer's precompression recommendations must be followed. When the temperature at installation differs from the temperature in the precompression recommendation, a correction shall be made.
- F. Manufacturer:
 - 1. Holz Rubber Company.
 - 2. Mercer Rubber Company.
 - 3. Proco Products, Incorporated.
 - 4. Or equal.

2.04 TOOLS, SPARE PARTS AND MAINTENANCE MATERIALS

- A. The duct system shall be furnished with the following:
 - 1. Names and addresses of all manufacturers of: Fiberglass reinforcements, resins, hardeners and components used to repair and maintain the FRP duct system.
- B. Material safety data sheets for all components must be furnished.

2.05 FIBERGLASS REINFORCED PLASTIC (FRP) DAMPERS

- A. Furnish and install where indicated on the drawings manually operated FRP dampers. Provide handle for manual operation and infinitely adjustable positive locking quadrant for balancing purposes. Dampers shall be flanged connection and fabricated from materials similar to those specified for ductwork above.
- B. Locking quadrants for manually operated dampers shall have a positive method of holding the damper in its selected position such as a bolt through both the quadrant and the lever arm. Systems using springs or other devices that can vibrate loose are not acceptable.
- C. Rating Conditions
 - 1. Maximum Temperature: 200 degrees F
 - 2. Velocity through Damper: Duct-mounted – 3000 fpm. Louver-mounted – 4000 fpm.
 - 3. Pressure Rating: Duct-mounted – same as ductwork. Louver-mounted – 2.5-in wg.
- 1. Allowable Leakage: With a differential pressure of 12-in wg.

Size (in Diameter)	Maximum Allowable Leakage (cfm)
72	200
66	186
60	172
54	158
42	130
36	50

24	25
18	20

4. One damper of each size shall be shop tested at 12-in wg differential and shall meet the above leakage. Submit damper test report to the Owner's Designated Representative. Damper shall not be shipped until approved by the Owner's Designated Representative .
- D. Equipment isolation dampers, header separation manifold dampers, and exhaust branch duct balancing dampers shall be manufactured using the same materials as the ductwork. Round dampers shall be single butterfly blade type. Damper blade shall be non-binding with blade-to-wall clearance of not greater than 0.05 inch. Construct damper bodies from a one-piece mold with flanges molded to the barrel. Shafts shall be fitted with seal roller or ball bearing external to the air stream and protected by a corrosion-resistant shaft seal. The bearing carriers shall be bonded to the damper barrel. Support the damper operator shaft with an external bearing mounted to the carrier bracket. Damper shafts and blade shall be constructed of FRP or FRP-coated stainless steel.
 - E. Rectangular control dampers shall be opposed-blade or parallel-blade type as indicated on the Drawings with external linkage and sealed shaft bearings (out of airstream). Where not called out on Drawings, provide opposed-blade damper type. Rectangular back draft dampers shall be parallel-blade type with external linkage and sealed shaft bearings. Manual control damper will be supported on external bearings. Bearings may be either ball type or a pressed-fit Teflon onto the shaft. The shaft seal shall not have any bearing load applied to it. Damper shall also have locking quadrants with adjustable stops. Dampers shall be equal to Model 1108 as manufactured by Swartwout, or as indicated on the Drawings with dimensions indicated on the Drawings.
 1. Materials
 - a. Damper Assembly: Flame retardant fiberglass material using same materials as ductwork suitable to withstand continuous containment concentrations in airstream.
 - b. Bearings: PTFE or Teflon
 - c. Blade: FRP, 6-in wide × 1/8-in thickness minimum, parallel or opposed blade, as called out on Drawings.
 - d. Frame: 8-in deep × 2-in wide minimum FRP channel.
 - e. Axles: 3/4-in minimum diameter FRP rods, full length of damper size as shown on the Drawings.
 - f. Handle: Type 316 stainless steel, or FRP.
 - g. Pins: Type 316 stainless steel.
 - h. Blade Stops: FRP angles with elastomer seals suitable for use at the design conditions.
 - i. Bushings: Teflon.
 - j. Hardware: Type 316 stainless steel.
 - k. Angles: FRP.
 - l. Seals: Blade seals shall be Teflon type, mechanically attached to blade. Provide with 316SS jambseals and axle shaft seals.
 - m. Linkage: 316SS, out of airstream.

- F. Blast Gate Dampers: Fabricated from duct construction materials with reinforced core of foam or honeycomb. The finished gate thickness shall be not less than 7/8 inch. Finish gate's smooth surfaces and edges with accurate fit to the gate receiver. Size gates for not more than 50 pounds. Trim all excess material to minimize surface area. Provide a 100 percent seal gate receiver cover plate with corrosion-resistant hardware to be installed when the gate is removed. The gate receiver section may be fabricated as part of the duct to be fitted with bell ends for field bonding. Provide nylon blade position locking bolts bonded to the gate opening.
- G. Dimensions: As detailed on the Drawings.
- H. Manufacturer: Field-fabricated dampers shall not be acceptable. Dampers shall be factory manufactured from one of the following manufacturers. Each damper shall be labeled with manufacturer's name, model number and date of manufacture. Provide products of one of the following:
 - 1. Belco Mfg. Inc.
 - 2. Ershigs Incorporated.
 - 3. Bionomic Industries, Interchem Systems Division.
 - 4. Heil Process Equipment, Xerxes Corporation.
 - 5. Swartwout, Phillips Industries.
 - 6. Calgon Corporation.
 - 7. Or equal.

2.06 FRP TRANSITION PIECES

- A. Provide transition pieces as shown on Drawings and specified herein.
- B. Construction:
 - 1. Thickness of transition pieces shall be designed using a safety factor of 10 to 1 for pressure and 5 to 1 for vacuum service with the pressure classification listed below.
 - 2. Custom flanges shall be designed as required to connect to fans, coils, dampers and duct work. Coordinate flange sizes to match approved equipment dimensions.
- C. Pressure Classification: Manufacturer shall design transition pieces so that they shall be free from buckling, pulsing, warpage and sagging at design pressures.

2.07 LABELS

- A. The service of each duct along with an arrow indicating direction of flow shall be provided on each duct system, and all dampers shall be labeled.

2.08 HANGERS AND SUPPORTS

- A. All hangers, supports, fasteners and hardware shall be 316 stainless steel.
- B. Support FRP ductwork using details and methods described in the SMACNA Industrial Duct Construction Manual and as detailed on the contract drawings.
- C. Reinforce ductwork at support locations with extra layer of FRP equal thickness to duct thickness or 1/4-inch minimum. Reinforcement shall be 1/3 circumference of round ductwork and extend 6-inches in both directions from edge of duct support. As an

alternative, provide 1/4-inch minimum neoprene pad at contact point between FRP and metal duct support.

- D. Protect the duct from clamping force of strap hangers with a 1/4-inch-thick layer of neoprene pad.
- E. When anchors are required, they shall be externally bonded to the duct. Drive screws or other penetrations of the duct liner are not permitted.
- F. Maximum spacing of supports for FRP ductwork shall not exceed duct spacing as recommended by SMACNA for metal ductwork of similar sizes and in no case exceed 10 feet. All fittings, expansion joints and similar items shall be supported within 18-in of the joint unless otherwise noted.
- G. Provide supports which are independent of equipment, other ductwork and walls.
- H. Vibration isolation for hangers shall be as required by related Sections in this Division.

PART 3 EXECUTION

3.01 INSTALLATION

- A. All ductwork shall be fabricated and erected where shown on the Drawings or as specified herein. Ductwork shall be rigidly supported and secured in an approved manner.
- B. Install ductwork parallel to walls and/or roof and vertically plumb.
- C. Bracing and vibration isolators shall be installed, where necessary, to eliminate vibration, rattle and noise. Hangers shall be installed plumb and securely suspended from supplementary steel or inserts in concrete slabs. Lower ends of hanger rods shall be sufficiently threaded to allow for adequate vertical adjustment. Building siding and metal decking shall not be used to hang ductwork.
- D. The Contractor shall not install any equipment or materials until the Owner's Designated Representative has approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.
- E. Wherever ducts are divided, the cross-sectional area shall be maintained. All such changes must be approved and installed as directed by the Owner's Designated Representative or as approved on shop or erection drawings.
- F. During installation the open ends of ducts shall be closed to prevent debris and dirt from entering. Work shall be installed in accordance with the overall approved progress schedule and in cooperation with all other trades so there will be no delay to other trades.
- G. The Drawings of the air ducts and air risers indicate the general location for installation of the ducts and risers. Should additional offsets or changes in direction be made, these changes must be considered in the original bid and shall be installed at no additional cost to the Owner.
- H. All necessary allowances and provisions shall be made in the installation of the ducts for the structural conditions of the building. Ducts shall be transformed or divided as may be required. Wherever this is necessary, the cross-sectional area shall be maintained.

All of these changes, however, must be approved and ducts installed as directed by the Owner's Designated Representative or as approved on shop or erection drawings.

- I. The taper of all transformations shall be not more than 30 degrees.
- J. Do not remove or alter factory installed duct reinforcing ribs except as required to accommodate duct alterations due to unexpected field conditions. Notify the Owner's Designated Representative prior to starting any field modifications involving ductwork structural reinforcing members. Submit additional design calculations to demonstrate structural design integrity of ductwork and fittings requiring reinforcing modifications in the field.
- K. No ductwork or components shall be shipped prior to complete resin cure.
- L. Do not run any ductwork through elevator machine rooms, egress stairwells or electrical rooms, except for ductwork specifically serving the room.
- M. All materials and equipment shall be installed as shown and described herein and as may be required by the applicable codes of the state and city. Drawings do not attempt to show exact details of all ductwork, and no extra payment will be allowed for obstruction by work of other trades or local obstructions to the work under this Contract with require offsets. Where diagrams have been made to show duct connections, the Contractor is cautioned that these diagrams must not be used for obtaining material quantities.
- N. Changes in location of equipment or ductwork, advisable in the opinion of the Contractor, shall be submitted to the Owner's Designated Representative for review before proceeding with the work. All measurements and dimensions shall be verified at the site. All equipment shall be adjusted and left in a condition satisfactory to the Owner's Designated Representative.
- O. Any preparation of the structural components of the building required for equipment and material regarding this unit of the Contract shall be done by the particular affected trade and shall be done to the satisfaction of the Owner's Designated Representative.
- P. Slope ducts as indicated on the Drawings, a minimum of one sixteenth of an inch per linear foot of duct, toward the drains.

3.02 HANGERS

- A. Rectangular and Round Ductwork - Spacing and size of hangers shall be as required by the ductwork manufacturer or the SMACNA Industrial Duct Construction Manual and as detailed on the contract drawings whichever is more stringent. Ductwork support systems shall include restraints as required by the applicable building codes to withstand seismic loading. Design shall be provided by a professional engineer hired by the Contractor as specified in other sections of the specification.
- B. All hanger materials shall be Type 316 stainless steel.
- C. Perforated band iron or wire for supporting ducts will not be permitted. Ducts shall not be supported from furring, hung ceilings or from another duct or pipe.
- D. C-clamp type hangers shall be supplied with a retainer strap.
- E. Ductwork shall not come in contact with any of the ceiling construction or any other equipment in the ceiling cavity.

- F. FRP ductwork shall be properly anchored and supported from building structures. Each anchor shall consist of two semi-circular stainless steel bands around the duct bolted together vertically and horizontally. The structural supports or wall securement shall be 316 stainless steel and furnished and installed under this Section.
- G. Hanger system shall use threaded rod for adjustability.
- H. The following methods of hanger attachment to the building structure are NOT allowed. The numbers and letters refer to hanger methods shown in Figure 4-1, 4-2 and 4-3 of the 1985 edition of the HVAC Duct Construction Standards Metal and Flexible as published by SMACNA.
 - "T" - wrap around strap on open web joist.
 - "W" - bent over band on open web joist.
 - "14" - friction clamps.
 - "17" - bent wire in metal deck.
- I. Design of hangers shall include the effect of all loads applied to the duct as well as the load of the duct. These loads include, but are not limited to wind, snow, seismic and internal dirt or liquid buildup.
- J. Hangers shall not be supported from roof decking or bulb tees. Where required, provide supplemental steel to span between the building structure.

3.03 DUCTWORK FITTINGS AND ACCESSORY ITEMS

- A. Duct Elbows - Changes in direction and offsets shall be made in a gradual manner to facilitate streamline flow of air. All elbows shall have a centerline radius of not less than 1-1/2 times the width of the duct in the plane of the elbow unless noted otherwise on the contract drawings. For rectangular ductwork where full radius elbows cannot be installed or abrupt elbows are shown, provide abrupt elbows equipped with shop-installed solid or hollow, fiberglass air foil turning vanes unless heel is radiused. An access door shall be installed at each abrupt elbow, so located for easy access to turning vanes.

3.04 DAMPERS

- A. General - Install dampers at locations where it is necessary to regulate or control air flow volume and where shown on the Drawings. Install dampers in accordance with manufacturer's instructions. Do not compress or stretch damper frame into duct or opening. Handle damper using frame, and not with blades, actuator or shaft.
- B. Manual volume control dampers - Install wherever it may be necessary to regulate air volume for system air balancing and where shown on the Drawings. Volume control dampers shall be standard butterfly (round) or opposed blade type (rectangular) on channel frame with external damper position indicator, manual adjustment and position locking arrangement.
- C. Large area dampers - Provide intermediate type 316 stainless steel bracing and support for multiple section damper assemblies to support assembly weight and to hold against system pressure.

3.05 QUALITY

- A. All ductwork shall be free from pulsation, chatter, vibration or objectionable noise. After system is in operation, should these defects appear they shall be corrected by removing, replacing or reinforcing the work. Sound levels shall not exceed the minimum requirement as specified in ASHRAE - Systems Volume. No discreet tones will be allowed.
- B. The maximum allowable leakage of low pressure system shall be 5 percent of air volume.
- C. The maximum allowable leakage of high pressure systems shall be one percent of air volume when tested at 100 percent of the operating static pressure.
- D. FRP duct installer shall provide certification that complete duct system was leak tested in accordance with the specifications. The letter shall indicate measured duct leakage and demonstration that duct leakage is in accordance with the requirements of this specification.
- E. The Owner's Designated Representative reserves the right to reject acceptance of delivery of any or all pieces of equipment found upon inspection to have any or all of the following defects in the laminate:
 - 1. Blisters
 - 2. Chips
 - 3. Crazing
 - 4. Exposed glass
 - 5. Cracks
 - 6. Burned areas
 - 7. Dry spots
 - 8. Foreign matter
 - 9. Surface porosity
 - 10. Sharp discontinuity
 - 11. Trapped air
 - 12. Any item which does not satisfy the tolerances as specified.

3.06 CLEANING OF DUCTWORK

- A. All ductwork, outlets and other parts of the ductwork systems shall be maintained in a clean condition during installation.
- B. Complete ductwork systems shall be cleaned prior to testing and air balancing. Cheese cloth shall be secured over all openings of the ductwork system for entrapment of dirt during the cleaning operation.
- C. Thoroughly clean all parts of the installation at the completion of the work and prior to turning work over to Owner. All surface defects and scuff marks shall be removed or painted.

3.07 PAINTING

- A. Painting shall be performed under this Section and as required by related Sections.

3.08 TEST PORTS

- A. Where shown on the Drawings and where required for testing and balancing instrument insertion ports shall be provided. Size and location of ports shall be coordinated with the contractor performing air balancing. Ports shall be sealed with plastic snap lock plugs. When the ductwork will be insulated the port shall be extended to the face of the insulation and the vapor barrier sealed to the port. Locate test ports 10 duct diameters downstream from any inlet, elbow or any other transition or fitting to allow the air to smooth out and thereby obtain more accurate readings.
- B. In round ductwork provide 2 ports 90 degrees on centers. In rectangular ductwork provide ports as required by AABC or NEBB for a full traverse measurement.
- C. Locate ports as indicated on drawings. As a minimum, ports shall be provided in the following connections:
 - 1. All duct mains.
 - 2. All duct branches unless all connections are diffusers, registers, or grilles and the total can be calculated by summing the readings for all of the connections.
 - 3. At each duct drop.
- D. A main duct is defined as one of the following:
 - 1. A duct serving five or more outlets.
 - 2. A duct serving two or more branch ducts.
 - 3. A duct emanating from a fan or plenum.
 - 4. All remaining ducts are considered branch ducts.

3.09 FIELD QUALITY CONTROL

- A. Field-Supplied Test Sample:
 - 1. The Contractor shall provide a minimum of five sample specimens. Samples shall be submitted to the Vendor of the resins used in the duct construction process.
 - 2. All sample specimens shall be taken as directed by the Owner's Designated Representative at random locations from standard production ductwork available on the jobsite.
- B. Supplier's/Manufacturer's Services: The supplier's and/or manufacturer's representative for the material specified shall be present at the jobsite as requested by the Contractor for installation assistance, inspection and approval of the installation, testing, startup assistance, and inspection during normal operation.
- C. Testing, General:
 - 1. Prior to connection to equipment and before applying insulation, perform a dynamic pressure test on ductwork systems using a high-pressure blower with a calibrated orifice and monometer. Provide all necessary blowers, gauges, connections, and similar items required to perform the tests.
 - 2. Repair all leaks and retest until stipulated results are achieved.
 - 3. Advise the Owner's Designated Representative 48 hours in advance of each test. Failure to so notify will require that the test be rescheduled.

- D. Testing Requirements: Test systems at the same pressure as the duct pressure classification except positive. Maximum air loss shall not exceed 0.5 percent of rated flow.

3.10 EQUIPMENT IDENTIFICATION AND DUCTWORK LABELING

- A. Equipment identification and duct markers shall be part of the work of this Section and shall be provided at all ducts.

3.11 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 15990

HVAC – TESTING, ADJUSTING AND BALANCING

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish the necessary labor, materials, instruments, transportation and devices required to test, adjust and balance all HVAC systems as detailed herein and as shown on the HVAC Drawings. Each system shall be tested, adjusted and balanced as required to cause the systems to perform in accordance with the intent of the Drawings, the Control Sequences and this Section.
- B. Work Description - Refer to Section 15500 for a general description of work and to the following additional specific descriptions:
 - 1. Odor Control Exhaust Systems - The Testing, Adjusting and Balancing (TAB) Contractor shall be responsible for all testing and balancing of all new odor control exhaust ductwork so that airflows are balanced as indicated on the Contract Documents from the individual draw points inside the Thickener Building up to and including the odor control exhaust fans. System shall be balanced for both flow and pressure as defined herein.
- C. The TAB Contractor shall be responsible for reviewing all the HVAC Drawings and associated Sequences of Operation and accompanying specification information on the HVAC systems and the intended operation for every system.
- D. Test and balance air system and submit testing and balancing reports to the Engineer for review and approval. Re-balance when required by the Engineer, incorporating all changes and certify the systems have been tested and balanced to meet specified requirements. The tests shall demonstrate the specified capacities and operation of equipment and materials comprising the systems. Such tests other than as described herein, which are deemed necessary by the Engineer to indicate the fulfillment of the Contract, shall be made.
- E. The test and balance work shall comply with the requirements of this specification and all data required by this Section shall receive complete final approval by the Engineer before final payment is made.
- F. If, in the opinion of the Engineer, the TAB Contractor has not, will not, or cannot comply with the testing, balancing and adjusting requirements of this Section, the Engineer may advise the Owner to employ a qualified firm to perform such work at Contractor's sole expense.
- G. Related Sections – The following documents shall also govern the work under this Section.
 - 1. Division 1 — General Requirements.
 - 2. Section 15500 — HVAC General Provisions.

1.02 RELATED WORK

A. The Mechanical Contractor shall:

1. Install, startup, operate and check all Odor Control Exhaust systems prior to balancing work.
2. Provide the necessary personnel to assist the TAB Contractor during the balancing work and shall make all necessary adjustments and corrections to equipment and systems (i.e. add dampers, add pulleys and belts, etc.) as directed by the TAB Contractor.
3. Provide the necessary equipment to the TAB Contractor for making readily accessible all HVAC equipment and other devices requiring adjustment.

1.03 QUALITY ASSURANCE

A. TAB Contractor Qualifications

1. Testing, balancing and operation of the systems shall be performed by competent and experienced technicians, having formerly done similar work in this field and whose qualifications and performance shall be subject to the approval of the Engineer.
2. TAB work shall be performed by an AABC or NEBB certified agency, which is independent of all suppliers and installers on the particular job.
3. All TAB work shall be done under the supervision of registered mechanical engineers or AABC or NEBB certified test and balance engineers employed directly by the TAB Contractor. Supervisory personnel shall have at least 5 years' experience in TAB work.
4. Show five successfully completed projects of similar size and scope.
5. The TAB Contractor shall furnish all necessary calibrated instrumentation to adequately perform the specified services. An inventory of all instruments and devices in possession of the TAB Contractor may be required by the Engineer to determine the TAB Contractor's performance capability.
6. The TAB contractor shall be prepared to submit credentials and other evidence of qualifications, and work experience within 60 days after Contract award.

B. Test and Balancing Standards

1. AABC or NEBB requirements and recommendations.
2. Report forms for TAB work shall be as recommended by the AABC or the NEBB.

1.04 SUBMITTALS

A. Submit Pre-Qualifications, in accordance with Sections 01300 and 15500, with the following information:

1. Qualifications and experience information and data as detailed below. Include only qualifications and experience related to type of work described herein and as indicated on the drawings and other sections of the specifications. Specific emphasis shall be placed on past work experience associated with odor control exhaust systems.
2. Evidence of registration as certified AABC or NEEB TAB contractor where work is to be performed in the State of Texas.
3. Proposed testing schedules and procedures.

4. Preliminary draft "system" balancing reports.
- B. Testing and Balance Reports - Submit final Test Reports after completion of testing, adjusting and balancing work. Submit reports by building, individually bound. Each report per building shall have the following minimum information. Refer to Part 3 of this Section for testing procedures.
1. Cover Sheet - Provide the following general data in a format selected by the TAB Contractor:
 - a. Project Name
 - b. Project Location: address including City and State
 - c. Owner Contract Number
 - d. Building name
 - e. Project Engineer(s) Name
 - f. General Contractor Name
 - g. Mechanical Contractor Name
 - h. TAB Contractor Name, address and phone number
 - i. Printed Name, signature and seal/certification of responsible-in-charge TAB engineer/technician.
 - j. Dates tests were performed
 2. Preface - A general discussion of the systems, any abnormalities and problems encountered.
 3. Instrument List - The list of instruments including type, manufacturer, model #, serial number, range and calibration dates.
 4. Test Forms - Furnish test report data on 8-1/2-in by 11-in bond AABC or NEBB form paper in accordance with Sections 01300 and 15500. Submit format for recording data and receive approval prior to use.
 - a. Each test form header/footer shall include the following general information:
 - (i) Name of TAB Contractor.
 - (ii) Project Name and Address.
 - (iii) Dates tests were performed.
 - (iv) Building Name or Room Number or Zone Number.
 - (v) Instruments used to perform the test.
 - (vi) Name of test technician or test engineer.
 - b. Furnish, as a minimum, the following test data on the test forms for all HVAC equipment.
 5. Fans
 - a. Tag Number (as used in the HVAC Drawings)
 - b. Location
 - c. Manufacturers, model number and serial number.
 - d. All design and manufacturer's rated data.
 - e. Total air flow, cfm, design and actual.
 - f. Pressure, inches w.g., at inlet of each fan.
 - g. Pressure, inches w.g., at discharge of each fan.
 - h. External static pressure, inches w.g., design and actual.

- i. Total static pressure, inches w.g., design and actual.
 - j. Outlet velocity - fpm.
 - k. Fan RPM.
 - l. Maximum tip speed - fpm.
 - m. Submit the actual fan operating point on a copy of the fan shop drawing showing operating curve.
 - n. List the following data from all fan motors installed.
 - (i) Manufacturer model and size.
 - (ii) Motor horsepower, service factor and rpm.
 - (iii) Volts, phases, cycles and full load amps (one reading for each phase leg on 3 phase motors).
 - (iv) Efficiency.
6. Diagrams - Prepare 11-in by 17-in single line diagrams or 12-in by 18-in half size drawings showing all duct systems indicating all terminal air outlets including diffusers, grilles, registers, nozzles and other types of air supply, return or exhaust outlets. The minimum scale for diagrams showing the measurement points shall be 1/8-in=1-ft-0-in in the final form as submitted. The use of faxed copies of diagrams is not acceptable. Location of test points shown on the diagrams shall be clear and easy to locate on the diagram. The identification mark of the test points shall be the same as is shown on the test report showing the test data. The identification for test points shall include indication of the units served, and shall not have a duplicate in the project. All supply outlets shall be adjusted so that there are no drafts. Grille and register readings may be made by a vane anemometer, but diffuser readings shall be made by a flow hood or a velometer, using the tip recommended by the diffuser manufacturer. Each diagram sheet shall include the following information:
- a. Project Name and address.
 - b. Project Location: address including City and State
 - c. Owner Contract Number
 - d. Building name
 - e. TAB Contractor Name, address and phone number
 - f. Dates tests were performed
- C. All submittals shall contain a statement that Sections 15500, 15990 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.
- D. In general, corrections or comments or lack thereof, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of

construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.05 ENGINEERING SERVICES

- A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.
- B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

1.06 SCHEDULE AND PROCEDURES

- A. A complete schedule of balancing procedures for each of the buildings or systems shall be submitted in sufficient time in advance so that the Engineer, at their option, might arrange to observe these procedures as they progress. Before commencing with the balancing of the systems submit the methods and instruments proposed to be used to adjust and balance the air systems.
- B. Submit proposed testing programs at least 2 weeks prior to the scheduled test to assure agreement as to personnel and instrumentation required and scope of each testing program.

1.07 DRAWING REVIEW

- A. The TAB Contractor shall thoroughly review the location of all dampers, registers, grilles, etc. The purpose of the review is to finalize the optimum locations for dampers and test ports shown on the Drawings.

1.08 EQUIPMENT CURVES

- A. Fan Characteristics Charts: The HVAC and General Contractors shall provide to the TAB Contractor any require characteristic curve charts for all fans. Characteristic curve charts shall be not less than 8-1/2-in by 11-in and shall show the static pressure, capacity horsepower and overall efficiency for operating conditions from no load to 130 percent of specified load. The minimum size of the actual fan curve shall be no less than 6-in by 8-in. The use of faxed copies of curves is not acceptable.

1.09 GUARANTEE/WARRANTY

- A. The TAB work shall be guaranteed to be accurate and factual data, based on readings in the field. All test data shall be submitted within 14 working days of the performance of the test. Test data shall not be held until final completion, but shall be submitted on an interim basis as soon as the test or appropriate group of tests is finished.
- B. Provide extended warranty of 90 days after completion of test and balancing work, during which time Owner/Engineer/Owner's Representative may request a recheck or

resetting of equipment or systems which may not be performing satisfactorily. Provide technicians as required to perform additional testing and balancing.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Furnish gaskets, lubricants and other expendable materials required to be replaced during the execution of this work.
- B. Fixed-pitched pulleys required for fan adjustments shall be furnished on an exchange basis by the party responsible for the fan installation.
- C. Where test results indicate that air quantities at any system fan are below or in excess of the specified amount, the HVAC and General Contractors, at their own expense, shall change driving pulley ratio or shall make approved changes to obtain the specified or scheduled air quantities.
- D. Testing apparatus: Furnish plugs, caps, stops, valves, blowers and similar devices required to perform this work.
 - 1. Furnish anemometers, thermometers, gauges, voltmeters, ammeters, lachometers and similar instruments, not part of the permanent installation, but required to record the performance of the equipment and systems.
 - 2. Testing apparatus, not part of the permanent installation, shall remain the property of the Contractor, but made available to the Engineer.
 - 3. Instruments used for testing shall be certified accurate to within plus or minus 0.10-in wc for pressure. Calibration of the instruments shall be done within 7 days of testing for this project and henceforth every 30 days thereafter for the duration of the testing period. Certification of calibration shall be submitted to the engineer prior to starting the work.

PART 3 EXECUTION

3.01 START OF BALANCING

- A. The General Contractor shall notify the TAB Contractor and Engineer when systems become operational and ready for preliminary and final testing, adjusting and balancing.
- B. Final balancing shall not begin until system has been installed complete and is capable of normal operation. Provide personnel to assist in rough balance and calibration.
- C. If requested by Owner, testing, adjusting and balancing work shall be done in the presence of the Owner's Representative. Notify Owner's Representative at least two weeks prior to commencing balancing work.
- D. All grilles, dampers, fans and linkages shall be verified to be installed and operating.
- E. System shall be capable of operating under control as specified on Drawings and/or contained herein.
- F. TAB work shall be done under normal operating conditions of equipment. For example, if HVAC sequences of control indicate that fans shall run with associated motorized dampers at intake louver open, then fan shall be tested with intake damper open.

- G. Verify with straight edge that fan and motor shafts are parallel and that sheaves are in proper alignment.
- H. Verify that belts are properly tensioned when unit is operating with no excessive squeal at startup. If not correct, adjust sheaves or motor base accordingly.
- I. Check dampers on system are open, where required, prior to starting fans.
- J. Start fans, verify that rotation is correct. If rotation is incorrect coordinate with electrical contractor to switch power leads such that the motor rotates correctly.
- K. Check nameplate voltage on motor, compare to scheduled voltage. Notify the Engineer immediately of any discrepancies. Measure and record actual voltage across all power leads. Notify the Engineer of discrepancies immediately.
- L. Check motor nameplates full load amps, measure and record amperage across all power leads. If there are marked discrepancies in amperage draws between legs, notify the Engineer immediately.
- M. Measure and record fan and motor rpm. Check that motor rpm agrees with nameplate and scheduled rpm. Where a speed adjustment is required, the Mechanical Contractor shall make any required changes.
- N. If, upon commencing the work, the TAB Contractor finds that the systems are not ready, or if a dispute occurs as to the readiness of the systems, the TAB Contractor shall request an inspection to be made by the Engineer. This inspection shall establish to the satisfaction of the represented parties whether or not the systems meet the basic requirements for testing and balancing. Should the inspection reveal the notification to have been premature, all costs for the inspection and work previously accomplished by the TAB Contractor shall be paid for by the General Contractor. Furthermore, such items that are not ready for testing and balancing shall be completed and placed in operational readiness before testing and balancing services shall be recommenced.
- O. Leaks, damage and defects discovered or resulting from startup, testing and balancing shall be repaired or replaced to like-new condition with acceptable materials. Tests shall be continued until system operates without adjustments or repairs.

3.02 REQUIRED ACCURACY

- A. Air systems shall be balanced to be within the following limits of the capacity shown on the Drawings. Limits shall be applied to both individual components and to the system totals.
 - 1. Odor Control Exhaust Systems: (plus 5 percent)

3.03 TESTING PROCEDURES

- A. General
 - 1. The damper positions at the three existing duct taps called out on the Drawings and the rest of the odor exhaust system, including odor exhaust fan, were balanced and set in place by the TAB Contractor in Phase 1 work; however it is this Contractor's responsibility in this Phase 2 work to verify the airflows at each duct branch, existing and new, and at the odor exhaust fan meet the airflow requirements called out in the Drawings and Specifications after the installation of the new FRP ductwork in this Project. Where the airflow values deviate from the

Contract Document requirements, the following procedures shall be used to balance the odor exhaust system.

B. HVAC Air Systems Balance

1. Test and balance the exhaust air systems in accordance with AABC or NEBB Standards by the use of direct reading instruments such as an "anemotherm" or velometer which has been properly calibrated.
2. The sequence of air balancing shall be as follows:
 - a. First, establish air flow quantity at supply fan by main duct traverse.
 - b. Next, establish air flow quantities in main ducts and branches.
 - c. Finally, establish air flow quantities at outlets, using proportional balancing among branch outlets. All multiple opening systems shall be left with at least one "open low" inlet or outlet, to which all other system openings shall be proportionally balanced. The "open low(s)" on each system shall be indicated in the report.
 - d. After all outlets are adjusted to within the tolerances specified elsewhere in this Section, remeasure all system outlets, and retrace all branch and main ducts to establish final "as balanced" flows.
 - e. All main air ducts shall be traversed, using a Pitot tube and manometer. The manometer shall be calibrated to read two significant figures in all velocity pressure ranges. The static pressure reading at the traverse point shall be recorded for each successive traverse.
 - (i) A main duct is defined as either of the following:
 - (a) A duct serving five or more outlets.
 - (b) A duct serving two or more branch ducts.
 - (c) A duct emanating from a fan or plenum.
 - f. All other ducts are branch ducts.
 - g. The intent of this operation is to measure by traverse, the total air quantity handled by the fan and to verify the distribution of air to zones and to adjust system pressure to minimum level required to satisfy the farthest air outlet.
3. Adjust fan speeds if results of system capacity tests are not within tolerances specified and repeat Paragraphs 3.04A4c, d and e above, as required.
4. Mark all final balancing damper positions with a permanent marker and set in place.
5. Adjust automatic dampers to required settings as described in Sequence of Operation. Coordinate work with HVAC Controls Contractor to obtain required adjustment of HVAC controls for proper operation of HVAC systems.

C. Odor Exhaust Systems:

1. In odorous areas the following additional procedures shall be used in addition to those already described.
2. Odorous areas shall be those areas that are exhausted to odor control system, odor control dispersion stacks, or specifically noted as odorous areas.
3. Balance the exhaust system to the flows shown on the Drawings. Balance the space to maintain a 0.05-in w.g. negative pressure relative to the surrounding areas by adjusting the supply air to the space. If the final supply air quantity is below the flow specified, use this flow and pro-rate it for the various supply air devices, on an equal percentage basis.

4. Balancing shall be done with all doors to the area closed and all interrelated systems operating.
5. After completion of the system balancing the space negative pressures shall be rechecked. If the negative pressures have been reduced, the systems shall be rebalanced to provide the specified negative pressures. This process shall be repeated until the negative pressures are maintained.
6. In addition to the data required above, the following shall be included for odor control systems.
 - a. Required pro-rating of supply systems if any.
 - b. Differential pressure between the odorous space and all adjacent spaces and the outdoors.

3.04 REPORT FORMS

A. HVAC Air Systems

1. Furnish computer generated data tabulating the following:
 - a. System Identification. In each report, the supply, return and exhaust openings and traverse points shall be numbered and/or lettered to correspond to the numbers and letters used on the report data sheets and on the report diagrams.
 - b. Opening number, type, size and design flow rate. Indicate design flow rate and actual flow rate.
 - c. Quantity of air in cfm at each air outlet and inlet. Indicate design flow rate and actual flow rate.
 - d. Provide data in schematic format, indicating design and actual air flow rates at each inlet and outlet.

B. Adjust belts, sheaves and the alignment of fan equipment.

C. Where various combinations of sheaves must be installed on fan systems to achieve the correct air delivery, change the sheaves and continue to take successive readings until the correct combinations are installed.

D. Furnish computer generated data taken at each air moving device, to include fans, tabulating the following:

1. Building Name or Room Number or Zone Number.
2. HVAC Equipment Tag Name (as used in HVAC Drawings).
3. Fan system and/or zone number.
4. Room number or area name.
5. Size of outlet.
6. Type outlet.
7. Manufacturer of outlet.
8. The cfm at each outlet on system and corresponding cfm at each outlet as noted on the plans.
9. Percent deviation of the measured flow versus the design flow.
10. Indication of the branch and terminal that are the open/low that are the basis for balancing the remainder of the system

3.05 FINAL ACCEPTANCE

- A. At the time of final inspection, the TAB Contractor shall recheck, in the presence of the Engineer, specific and random selections of data recorded in the certified test-and-balance report.
- B. Points and areas for recheck shall be selected by the Engineer.
- C. Measurements and test procedures shall be the same as the original test and balance.
- D. Selections for recheck, specific plus random, shall not normally exceed 15 percent of the total number tabulated in the report, except where special air systems require a complete recheck for safety reasons.
- E. Specific systems for recheck shall include the following:
 - 1. Supply and exhaust in odorous areas.
- F. If the specific rechecks are more than 5 percent deviation from the report or specified flows, all of the systems, that require specific recheck, shall be rebalanced. If 5 percent or 5 of the random checks, whichever is less, exceeds a 10 percent deviation from the specified flows, the report shall be rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, a new certified test-and-balance report submitted, and a new inspection test made, all at no additional cost to the Owner.
- G. Each fan shall operate with no objectionable noise or vibration.

3.06 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16010

ELECTRICAL GENERAL PROVISIONS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials and equipment required to install, test and provide an operational, electrical system as specified and as shown on the Drawings.
- B. The work shall include furnishing, installing and testing the equipment and materials detailed in Division 16.
- C. The work shall include furnishing and installing the following:
 - 1. Conduit, wire and field connections for all motors, motor controllers, control devices, control panels and electrical equipment furnished under other Divisions. The CONTRACTOR shall coordinate with the supplier of electrical equipment specified under other Divisions.
 - 2. Conduit, wiring and terminations for all field-mounted instruments furnished and mounted under other Divisions, including process instrumentation primary elements, transmitters, local indicators and control panels. Lightning and surge protection equipment wiring at process instrumentation transmitters. Install vendor furnished cables specified under other Divisions.
 - 3. A complete raceway system for the Data Highway Cables and specialty cable systems. Install the Data Highway Cables and other specialty cable systems in accordance with the system Manufacturers' installation instructions. Review the raceway layout, prior to installation, with the computer system supplier and the cable Manufacturer to ensure raceway compatibility with the systems and materials being furnished. Where redundant cables are furnished, install cables in separate raceways.
 - 4. Conduit, wiring and terminations for variable frequency drives, harmonic filters, transformers and power factor correction capacitors furnished and mounted under other related Divisions.
 - 5. Power wiring for all heating, ventilating, and air conditioning equipment furnished under other related Divisions, including power wiring for 120 Volt unit heater motors and thermostats. Refer to HVAC Drawings for the locations of 120 Volt unit heater thermostats and provide a 3/4-in C, 2 No. 12 and 1 No. 12 GRD between each heater and its respective control thermostat.
 - 6. Furnish and install precast electrical and instrumentation manholes, handholes and light pole bases.
 - 7. Furnish and install electrical and instrumentation manhole and handhole frames and covers.
 - 8. Modifications to existing control systems including installation of auxiliary motor starter contacts, relays, switches, etc, as required to provide the control functions or inputs as shown on the Drawings. Obtain the existing equipment shop drawings from the OWNER before attempting to make any modifications to the existing equipment wiring. Verify all existing wiring and connections for correctness. If

Record Drawings are not available, trace all circuits in the field and develop the wiring diagrams necessary for completion of the work. Document all changes made to the wiring diagrams and return a marked-up set of Record Drawings to the OWNER after the work is complete.

9. Coordinate the sequence of demolition with the sequence of construction to maintain plant operation in each area. Remove and demolish equipment and materials in such a sequence that the existing and proposed plant will function properly with no disruption of treatment.
10. Modifications to existing motor control centers, switchboards, panelboards and motor controllers including installation of circuit breakers, etc, or disconnection of circuits as required to provide the power supplies to new and existing equipment to maintain the plant in operation.
11. All bidders shall visit the site of the project, prior to submitting a bid, and satisfy themselves as to any question that they might have, relating to existing equipment, condition or construction.

- D. Provide all electrical relocation work associated with the relocation of equipment for the existing and new facilities, including disconnecting all existing wiring and conduits and providing new wiring and conduit to the relocated equipment.

1.02 SUBMITTALS

- A. Submit shop drawings in accordance with Division 1 for equipment, materials and other items furnished under Division 16, and as indicated in the individual specification sections.
- B. The CONTRACTOR shall check shop drawings for accuracy and contract requirements prior to submittal. Shop drawings shall be stamped with the date checked and a statement indicating that the shop drawings conform to Specifications and Drawings. Shop drawings shall be organized by specification section, with one specification section per transmittal. Each submittal shall be complete, contain all of the items listed in the specification section, and shall be clearly marked to indicate which items are applicable on each cut sheet page. This statement shall also list all exceptions to the Specifications and Drawings. Shop drawings, not so checked and noted, will be returned unreviewed.
- C. If however, in the opinion of the CONTRACTOR, a hardship of equipment delay or delivery of a specific item would delay the project through no fault of the CONTRACTOR, the CONTRACTOR may request an early review of that equipment or material, clearly stating the reason for separate approval. The approval of such material or equipment must not be dependent upon the approval of other equipment or materials to be submitted later, such as the Power System Study, etc.
- D. It shall be the CONTRACTOR's responsibility to check for conformance with the Specifications and Drawings, all as contained within the Contract Documents. Errors and omissions on approved shop drawings shall not relieve the CONTRACTOR from the responsibility of providing materials and workmanship required by the Specifications and Drawings.

- E. All dimensions shall be field verified at the job site and coordinated with the work of all other trades.
- F. Material shall not be ordered or shipped until the shop drawings have been approved. Shop Drawings, O&M Manuals, and other documentation, shall be submitted as listed in each of the Electrical Specification Sections.
 - 1. Submit operations and maintenance data for equipment furnished under this Division, in accordance with Division 1. The manuals shall be prepared specifically for this installation and shall include catalog data sheets, drawings, equipment lists, descriptions, parts lists, etc, to instruct operating and maintenance personnel unfamiliar with such equipment.
 - 2. Manuals shall include the following as a minimum:
 - a. A comprehensive index.
 - b. A complete "As-Built" set of approved shop drawings.
 - c. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data.
 - d. A table listing of the "as left" settings for all timing relays and alarm and trip setpoints.
 - e. System schematic drawings "As-Built", illustrating all components, piping and electric connections of the systems supplied under this Section.
 - f. Detailed service, maintenance and operation instructions for each item supplied.
 - g. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
 - h. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.
 - i. Complete parts list with stock numbers, including spare parts.
- G. Record Drawings shall be promptly furnished when the equipment installation is complete. Payment will be withheld until Record Drawings have been furnished and approved.
- H. At the time of delivery of the equipment, the CONTRACTOR shall have an approved shop drawing in possession for the OWNER's Inspector, and OWNER's Engineer, for verification.

1.03 REFERENCE STANDARDS

- A. Electric equipment, materials and installation shall comply with the National Electrical Code (NEC) and with the latest edition of the following codes and standards:
 - 1. Austin Water (AW) Facility Engineering Standards and Specifications
 - 2. National Electrical Safety Code (NESC)
 - 3. Occupational Safety and Health Administration (OSHA)
 - 4. National Fire Protection Association (NFPA)
 - 5. National Electrical Manufacturers Association (NEMA)
 - 6. American National Standards Institute (ANSI)

7. Insulated Cable Engineers Association (ICEA)
8. Instrument Society of America (ISA)
9. Underwriters Laboratories (UL)
10. Factory Mutual (FM)
11. Institute of Electrical Engineers (IEEE)

- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.
- C. All material and equipment, for which a UL standard exists, shall bear a UL label. No such material or equipment shall be brought onsite without the UL label affixed.
- D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents will take precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between Laws and Regulations, the higher performance requirement shall be binding on the CONTRACTOR, unless otherwise directed by the OWNER/ENGINEER.
- E. In accordance with the intent of the Contract Documents, the CONTRACTOR accepts the fact that compliance with the priority order specified shall not justify an increase in Contract Price or an extension in Contract Time nor limit in any way, the CONTRACTOR's responsibility to comply with all Laws and Regulations at all times

1.04 AREA CLASSIFICATION AND ENCLOSURE TYPES

- A. Unless otherwise specified herein or shown on the Drawings, electrical enclosures and associated installations shall have the following ratings:
 1. NEMA 1 for dry, non-process indoor above grade locations (i.e. administration areas, laboratories, control rooms, storage rooms).
 2. NEMA 7 (and listed for use in the area classifications shown) for "Class I Div. 1 Group D" and "Class I Div. 2 Group D" hazardous locations shown on the Drawings.
 3. NEMA 4X 316 Stainless Steel enclosures, suitable for corrosive areas, shall be provided for all other locations on the project. PVC enclosures shall be used for Chlorine and Caustic Rooms.

1.05 HAZARDOUS AREAS

- A. Equipment, materials and installation in areas designated as hazardous on the Drawings shall comply with NEC Articles 500, 501, 502 and 503.
- B. Equipment and materials installed in hazardous areas shall be UL listed for the appropriate hazardous area classification.

1.06 CODES, INSPECTION AND FEES

- A. Equipment, materials and installation shall comply with the requirements of the local authority having jurisdiction.
- B. Obtain all necessary permits and pay all fees required for permits and inspections.

1.07 TESTS AND SETTINGS

- A. Test systems and equipment furnished under Division 16 and repair or replace all defective work. Make adjustments to the systems and instruct the OWNER's personnel in the proper operation of the systems.
- B. Make the following minimum tests and checks prior to energizing electrical equipment:
 - 1. Mechanical inspection, testing and setting of circuit breakers, disconnect switches, motor starters, control equipment, etc for proper operation.
 - 2. Test grounding system as specified in Division 16.
 - 3. Test motor control centers as specified in Division 16.
 - 4. Test 600 volt wires and cables as specified in Division 16.
 - 5. Check wire and cable terminations for tightness.
 - 6. Check motor nameplates for correct phase and voltage. Check bearings for proper lubrication.
 - 7. Check the ampere rating of thermal overloads for motors and submit a typed record to the OWNER/ENGINEER of same, including MCC cubicle location and load designation, motor service factor, horsepower, full load current and starting code letter. If inconsistencies are found, new thermal elements shall be supplied and installed.
 - 8. Check rotation of motors prior to energization. Disconnect driven equipment if damage could occur due to wrong rotation. If it rotates in the wrong direction, correct it.
 - 9. Check interlocking, control and instrument wiring for each system and/or part of a system to prove that the system will function properly as indicated by schematic and wiring diagrams.
 - 10. Verify all terminations at transformers, equipment, capacitor connections, panels, and enclosures by producing a 1 2 3 rotation on a phase sequenced motor when connected to "A", "B" and "C" phases.
 - 11. Verify motor power factor capacitor ratings.
- C. Testing shall be scheduled and coordinated with the OWNER/ENGINEER at least two weeks in advance. Provide qualified test personnel, instruments and test equipment.
- D. Refer to the individual equipment sections for additional specific testing requirements.
- E. Make adjustments to the systems and instruct the OWNER's personnel in the proper operation of the systems.

1.08 INTERPRETATION OF DRAWINGS

- A. The Drawings are not intended to show exact locations of conduit runs. Coordinate the conduit installation with other trades and the actual supplied equipment.
- B. Install each 3 phase circuit in a separate conduit unless otherwise shown on the Drawings.
- C. Unless otherwise approved by the OWNER/ENGINEER, conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed.
- D. Where circuits are shown as "home-runs" all necessary fittings and boxes shall be provided for a complete raceway installation.
- E. Verify the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation.
- F. Except where dimensions are shown, the locations of equipment, fixtures, outlets and similar devices shown on the Drawings are approximate only. Exact locations shall be determined by the CONTRACTOR and approved by the OWNER/ENGINEER during construction. Obtain information relevant to the placing of electrical work and in case of any interference with other work, proceed as directed by the OWNER/ENGINEER and furnish all labor and materials necessary to complete the work in an approved manner.
- G. Circuit layouts are not intended to show the number of fittings, or other installation details. Furnish all labor and materials necessary to install and place in satisfactory operation all power, lighting and other electrical systems shown.
- H. Redesign of electrical or mechanical work, which is required due to the CONTRACTOR's use of an alternate item, arrangement of equipment and/or layout other than specified herein, shall be done by the CONTRACTOR at their own expense. Redesign and detailed plans shall be submitted to the OWNER/ENGINEER for approval. No additional compensation will be provided for changes in the work, either their own or others, caused by such redesign.
- I. Raceways and conductors for lighting, switches, receptacles and other miscellaneous low voltage power and signal systems as specified are not shown on the Drawings. Raceways and conductors shall be provided as required for a complete and operating system. Refer to riser diagrams for signal system wiring. Homeruns, as shown on the Drawings, are to assist the CONTRACTOR in identifying raceways to be run exposed and raceways to be run concealed. Raceways installed exposed shall be near the ceiling or along walls of the areas through which they pass and shall be routed to avoid conflicts with HVAC ducts, cranes hoists, monorails, equipment hatches, doors, windows, etc. Raceways installed concealed shall be run in the center of concrete floor slabs, above suspended ceilings, or in partitions as required.
- J. The CONTRACTOR shall run all conduit and wire to PLC termination cabinets, where designated on the Drawings. The conduit and wire as shown on the interface Drawings may not necessarily be shown on the floor plan.

- K. Install conductors carrying low voltage signals (typically twisted shielded pair cables) in raceways totally separate from all other raceways containing power or 120 volt control conductors.
- L. Raceways and conductors for low voltage (120 Volts) thermostats controlling HVAC unit heaters, exhaust fans and similar equipment are not shown on the Drawings. Provide raceways and conductors between the thermostats, the HVAC equipment and the motor starters for a complete and operating system. Raceways shall be installed concealed in all finished space and may be installed concealed or exposed in process spaces. Refer to the HVAC Drawings for the locations of the thermostats.
- M. Raceways and conductors for the fire alarm, sound and page party systems are not shown on the Drawings. Provide raceways and conductors as required by the system Manufacturer for a complete and operating system. Raceways shall be installed concealed in all finished spaces and may be installed exposed or concealed in process spaces.

1.09 PHASE BALANCING

- A. The Drawings do not attempt to balance the electrical loads across the phases. Circuits on motor control centers and panelboards shall be field connected to result in evenly balanced loads across all phases.
- B. Field balancing of circuits shall not alter the conductor color coding requirements as specified in Division 16.

1.10 SIZE OF EQUIPMENT

- A. Investigate each space in the structure through which equipment must pass to reach its final location. Coordinate shipping splits with the Manufacturer to permit safe handling and passage through restricted areas in the structure.
- B. The equipment shall be kept upright at all times during storage and handling. When equipment must be tilted for passage through restricted areas, brace the equipment to ensure that the tilting does not impair the functional integrity of the equipment.

1.11 RECORD DRAWINGS

- A. As the work progresses, legibly record all field changes on a set of Project Contract Drawings, hereinafter called the "Record Drawings". The Record Drawings and Specifications shall be kept up to date throughout the project.
- B. Record Drawings shall accurately show the installed condition of the following items:
 - 1. One-line Diagram(s).
 - 2. Raceways and pullboxes.
 - 3. Conductor sizes and conduit fills.
 - 4. Panel Schedule(s).
 - 5. Control Wiring Diagram(s).
 - 6. Lighting Fixture Schedule(s).

7. Lighting fixture, receptacle and switch outlet locations.
 8. Underground raceway and duct bank routing.
 9. Plan view, sizes and locations of switchgear, distribution transformers, substations, motor control centers and panelboards.
- C. Submit a typical example of a schedule of control wiring raceways and wire numbers, including the following information:
1. Circuit origin, destination and wire numbers.
 2. Field wiring terminal strip names and numbers.
- D. As an alternate, submit a typical example of point-to-point connection diagrams showing the same information, may be submitted in place of the schedule of control wiring raceways and wire numbers.
- E. Submit the Record Drawings and the schedule of control wiring raceways and wire numbers (or the point-to-point connection diagram) to the OWNER/ENGINEER.
- 1.12 EQUIPMENT INTERCONNECTIONS
- A. Review shop drawings of equipment furnished under other related Divisions and prepare coordinated wiring interconnection diagrams or wiring tables. Submit copies of wiring diagrams or tables with Record Drawings.
- B. Furnish and install all equipment interconnections.
- 1.13 MATERIALS AND EQUIPMENT
- A. Materials and equipment shall be new, except where specifically identified on the Drawings to be re-used.
- B. Material and equipment of the same type shall be the product of one Manufacturer and shall be UL listed.
- C. All hardware for mounting boxes and equipment, such as racks, brackets, washers, springs, nuts, etc, shall be of 316 stainless steel.
- D. The CONTRACTOR shall be responsible for all material, product, equipment and workmanship being furnished by them for the duration of the project. The Contractor shall replace the equipment if it does not meet the Contract Documents.
- E. Warrant all equipment furnished under Division 16 – Electrical. Refer to individual equipment sections for additional warranty items.
- 1.14 EQUIPMENT IDENTIFICATION
- A. Identify equipment (disconnect switches, separately mounted motor starters, control stations, etc) furnished under Division 16 with the name of the equipment it serves. Motor control centers, control panels, panelboards, switchboards, switchgear, junction or terminal boxes, transfer switches, etc, shall have nameplate designations as shown on the Drawings.

- B. All nameplates shall be laminated plastic, black lettering on a white background, attached with stainless steel screws.
- C. Nameplates shall be engraved, laminated plastic, not less than 1/16-in thick by 3/4-in by 2-1/2-in.
- D. Nameplates shall be 316 SS screw mounted to all enclosures. Screws on NEMA 4 enclosures shall be epoxy sealant coated. Epoxy adhesive or foam tape is not acceptable.

PART 2 EXECUTION

2.01 SLEEVES AND FORMS FOR OPENINGS

- A. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all necessary slots for electrical work and form before concrete is poured.
- B. Exact locations are required for stubbing-up and terminating concealed conduit. Obtain shop drawings and templates from equipment vendors or other Subcontractors and locate the concealed conduit before the floor slab is poured.
- C. Where setting drawings are not available in time to avoid delay in scheduled floor slab pours, the OWNER/ENGINEER may allow the installations of such conduit to be exposed. Requests for this deviation must be submitted in writing. No additional compensation for such change will be allowed.
- D. Seal all openings, sleeves, penetration and slots as specified in Division 16.

2.02 CUTTING AND PATCHING

- A. Cutting and patching shall be done in a thoroughly workmanlike manner and be in compliance with modifications and repair to concrete as specified in Division 3. Saw cut all concrete and masonry prior to breaking out sections.
- B. Core drill holes in concrete floors and walls as required.
- C. Install work at such time as to require the minimum amount of cutting and patching.
- D. Do not cut joists, beams, girders, columns or any other structural members.
- E. Cut opening only large enough to allow easy installation of the conduit.
- F. Patching to be of the same kind and quality of material as was removed.
- G. The completed patching work shall restore the surface to its original appearance or better.
- H. Patching of waterproofed surfaces shall render the area of the patching completely waterproofed.
- I. Remove rubble and excess patching materials from the premises.

- J. When existing conduits are cut at the floor line of wall line, they shall be filled with grout of suitable patching material.
- K. If a CONTRACTOR damages concealed conduits, it is the CONTRACTOR'S responsibility to make all necessary repairs at no cost to the OWNER.

2.03 INSTALLATION

- A. Any work not installed according to the Drawings and this Section shall be subject to change as directed by the OWNER/ENGINEER. No extra compensation will be allowed for making these changes.
- B. Electrical equipment shall be protected at all times against mechanical injury or damage by water. Electrical equipment shall not be stored outdoors. Electrical equipment shall be stored in dry permanent shelters. Do not install electrical equipment in its permanent location until structures are weather-tight. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and tested as directed by the OWNER/ENGINEER or shall be replaced at no additional cost at the OWNER/ENGINEER's discretion.
- C. Equipment that has been damaged shall be replaced or repaired by the equipment Manufacturer, at the OWNER/ENGINEER's discretion.
- D. Repaint any damage to the factory applied paint finish using touch-up paint furnished by the equipment Manufacturer. If the metallic portion of the panel or section is damaged, the entire panel or section shall be replaced, at no additional cost to the OWNER.

2.04 MANUFACTURER'S SERVICE

- A. Provide Manufacturer's services for testing and Start-Up of the equipment as listed in each individual Specification Section.
- B. Testing and Start-Up shall not be combined with training. Testing and Start-Up time shall not be used for Manufacturer's warranty repairs.

2.05 TESTING

- A. Test systems and equipment furnished under Division 16 and repair or replace all defective work. Make adjustments to the systems and instruct the OWNER's personnel in the proper operation of the systems.
- B. Make the tests and checks prior to energizing electrical equipment in accordance with the paragraph on Test and Settings, and the individual Specification sections.
- C. Testing shall be scheduled and coordinated with the OWNER/ENGINEER at least two weeks in advance. Provide qualified test personnel, instruments and test equipment, including Manufacturer's services, as specified in the individual Specification sections.
- D. Where test reports show unsatisfactory results, the OWNER/ENGINEER may require the removal of all defective or suspected materials, equipment and/or apparatus, and their

replacement with new items, all at no cost to the OWNER. The CONTRACTOR shall bear all cost for any retesting.

2.06 TRAINING

- A. The CONTRACTOR shall provide Manufacturer's training as specified in each individual section of the Specifications.

PART 3 EXECUTION

3.01 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16012
IDENTIFICATIONS

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish and install tags/nameplate on all equipment, devices, instruments, J-boxes, Panel boards and conductors marking as indicated on the Drawings and specified herein. Major equipment, other than conduit system, shall be furnished with nameplates in accordance with their individual specifications.

1.02 RELATED REQUIREMENTS

- A. Work as called for on PLANS, or in this or other Specification Sections.

PART 2 PRODUCTS

2.01 MATERIALS/CONSTRUCTION

- A. Wire Markers
 - 1. Wire markers shall be as specified in Division 16 "Wire Tagging"
- B. NAMEPLATES
 - 1. Nameplates:
 - a. Externally mark electrical equipment by means of suitable nameplates identifying each and the equipment served.
 - b. Provide each piece of equipment with a white phenolic nameplate with 3/16-inch high black lettering secured to front of equipment.
 - c. Supply blank nameplates for spare units and used spaces.
 - d. Actual nameplate legend, which may consist of up to three lines, will be provided to the ENGINEER on submittals.
 - 2. Nameplate Fasteners: Fasten nameplates to equipment only by means of appropriate 316 SS screws.
 - a. Stick-ons or adhesives are not allowed on the outside of a panel.
 - b. Machine printed stick-on labels are allowed inside of and/or on the backplane of a panel.
 - 3. Nameplate Information: In general, the following information is to be provided for the types of electrical equipment as listed.
 - a. Switchgear, Motor Control Centers and Distribution Panel boards: On the mains, identify the piece of equipment, the source, and voltage characteristics, i.e., 480V, 3PH, 3W, etc. For each branch circuit protective device, identify the load served and the primary side circuit number.
 - b. Transformers: Identify the service source, load served and transformer designation.
 - c. Panel boards: Identify the service source, Panel board designation and voltage characteristics.

4. Panel boards:
 - a. Prepare a neatly typed circuit directory behind clear heat-resistant plastic for each panel board.
 - b. Identify circuits by equipment served and by room numbers, where room numbers exist.
 - c. Use equipment names and room numbers selected by the ENGINEER; names and numbers may be different from those shown on plans.
 - d. Indicate spares and spaces with light, erasable pencil markings.
 - e. Provide a final set of the panel schedule in the O&M manuals.
 - f. Provide a CD with the file for each Panel board to the OWNER with the O&M manual.
 5. Boxes, Small Equipment:
 - a. Pull boxes, J-boxes and similar items shall be marked with Nameplates.
 6. Wall Switches: Engrave the switch plate of the switch with the function of the switch.
- C. Power Outlets, Switches, and Pilot Devices
1. Mark power outlets with voltage, phase, panel name, and circuit number.
 2. Identify all wall switches, disconnect switches, etc. with nametags, circuits served, and panel origin, list to be approved by OWNER/ENGINEER.
 3. Identify all push-button stations with their functions and equipment served.

PART 3 EXECUTION

3.01 ERECTION, INSTALLATION, AND APPLICATION INSTRUCTIONS

- A. Furnish and install nameplates for all Panel boards, motor starters, motor control center cubicles, disconnect switches, instrument panels, dry type transformers and control stations.
- B. Engrave the equipment designation, (e.g., "Starter Pump P1"), on nameplates in 3/16-inch black letters on white background of laminated phenolic unless specified otherwise in the equipment section. All switches, indicating lights, pushbuttons, meters and parameter indicators on panels shall be clearly identified with its function or tag, as required. Identification list to be approved by plant personnel through the ENGINEER.
- C. Stainless Steel tags shall be used on instrument, motors and other devices, as applicable. The tags shall be affixed to the instrument with drive pins or stainless steel chain in such a manner that it does not need to be removed to install the instrument. Motors shall carry the tag assigned to its driven equipment.

3.02 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16020

UTILITIES

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish and install necessary materials and make arrangements for the connection of utilities for the project.
- B. The required utilities are:
 - 1. Water service and meter
 - 2. Electric power service and meter
 - 3. Telephone line service
 - 4. DSL

1.02 RELATED REQUIREMENTS

- A. Work as called for on PLANS, or in this or other Specification Sections.

PART 2 PRODUCTS

2.01 FUNCTIONAL REQUIREMENTS

- A. The CONTRACTOR shall coordinate with all required utilities to provide dedicated services.
 - 1. Costs: Owner shall pay Electric Utility directly for the cost of the transformer, overhead electric modifications, medium voltage cables to the transformer and termination of the medium voltage cables. The Contractor shall provide the electric manhole, duct bank, transformer pads, conduit from transformer to meter cabinet, and all other accessories not specifically identified as paid for by the OWNER.
 - 2. Transfer: Account shall be transferred to the OWNER at time of final acceptance of the WORK.

2.02 TOOLS, SPARE PARTS AND ACCESSORIES (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. CONTRACTOR and/or ENGINEER shall comply with all service installation standards of the serving utility companies.
- B. Entrance must be coordinated with the OWNER/ENGINEER. Provide materials and equipment required to connect the project service to the system. Coordinate with Electric Company for requirements of power service.

- C. CONTRACTOR to follow the mechanical construction schedule, electrical equipment shall be energized on time. Delay to the Start-Up shall not be caused due to Electrical CONTRACTOR lack of coordination.
- D. CONTRACTOR to minimize interruption of service. CONTRACTOR to coordinate with OWNER prior any interruption per Division 1.

3.02 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16060

ACCEPTANCE TESTING AND CALIBRATION

PART 1 GENERAL

1.01 SUMMARY

- A. This section provides the guidelines for testing of electrical equipment, cable, protective relays, circuit breakers, motor control centers, motors, and related apparatus used in the project's electrical system. This specification does not release the CONTRACTOR or vendor from any further testing required for safe and satisfactory operational commissioning of all electrical and related equipment. All tests shall be completely recorded on applicable, developed forms for the test and calibration requirements.
- B. CONTRACTOR shall provide and pay the cost of electrical testing by an independent testing firm. Testing firm shall have a minimum of five years of experience in providing acceptance testing for water/wastewater treatment plants. Testing shall be performed per the latest International Electrical Testing Association (NETA) standard.
- C. The CONTRACTOR shall immediately correct all deficiencies discovered during testing and calibration.

1.02 RELATED REQUIREMENTS

- 1. DIVISION 16 Sections---in entirety.
- 2. DIVISION 17 Sections---in entirety.
- 3. Other DIVISIONs related and/or incorporating packaged mechanical/process systems containing electrical, instrumentation and controls (EIC) work.

1.03 REFERENCES

- A. InterNational Electric Testing Association Standards (NETA) for acceptance testing of Electrical Distribution Apparatus, Publication 2.001, and IEEE Publication No. 141, are hereby made a part of this section, unless otherwise modified herein.
- B. References, accordingly, as designated per related equipment specification in all Sections per Division 16 and as required/designated per Division 17.
- C. NETA Maintenance Testing Specifications for electrical power distribution equipment and system (latest edition).

1.04 SUBMITTALS

- A. ALL testing results and calibrations shall be summarized and tabulated in final Testing and Calibration Report/s certified by the testing technician/s. Final Report/s shall be submitted per Division 1.
- B. The report shall include the following:
 - 1. Description, purpose, basis and scope of the testing and/or calibration.

2. Field data sheet showing all visual, mechanical and electrical inspection done on the equipment. The data sheet shall show check mark and values of all the testing done, a description of the instrument used for testing and document date of instrument certified calibration (current/valid within the last calendar year) per NIST standards. Where applicable and/or required, show and provide schematic, diagram or drawing of the testing configuration / setup. Utilize project contract Drawings as applicable.
3. A summary of the deficiency, concern, repairs and recommendation/resolution.
4. A table showing the final settings of all the adjustable equipment tested.
5. All the testing values shall be in accordance with the latest NETA standard

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

- A. Air switches – Low voltage: Electrical Tests.
 1. Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground for one (1) minute. Test voltage and minimum resistances shall be in accordance with NETA Standard.
 2. Perform contact-resistance test across each switch blade and fuse holder, or perform thermographic survey in accordance with the latest NETA Standard.
- B. Transformers - Dry type: Small Transformers: Dry-Type, Air Cooled (600 Volt and below) (less than 100 kVA single-phase or 300 kVA three-phase).
 1. Inspect for physical damage, broken insulation, tightness of connections, defective wiring, and general condition.
 2. Thoroughly clean unit prior to making any tests.
 3. Perform insulation-resistance test. Calculate polarization index. Measurements shall be made from winding-to-winding and windings-to-ground. Test voltages and minimum resistance shall be in accordance with NETA Standard. Results to be temperature corrected in accordance with NETA Standard.
 4. Verify that the transformer is set at the specified tap.
- C. Cables – low-voltage, 600V maximum: Electrical Tests.
 1. Perform resistance measurements through bolted connections with low-resistance ohmmeter, if applicable, in accordance with latest NETA standard.
 2. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one minute.
 3. Perform continuity tests to insure correct cable connection.
- D. Circuit Breakers – Air, Insulated Case/Molded Case: Electrical Tests.
 1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with latest NETA standard.

2. Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed and across each open pole for one minute. Test voltage shall be in accordance with Manufacturer's published data or latest NETA standard.
- E. Perform a contact/pole-resistance test.
1. Perform adjustments for final setting in accordance with coordination study.
 2. Determine long-time pickup and delay by primary current injection.
 3. Determine short-time pickup and delay by primary current injection.
 4. Determine ground-fault pickup and time delay by primary current injection.
 5. Determine instantaneous pickup by primary current injection.
 6. Perform minimum pickup voltage test on shunt trip and close coils in accordance with latest NETA standard.
 7. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.
 8. Verify operation of charging mechanism.
- F. Protective Relays: Electrical Tests.
1. Perform insulation-resistance test on each circuit-to-frame. Do not perform this test on solid-state devices.
 2. Perform the following tests on the nominal settings specified by the electrical Engineer of Record:
 - a. Pickup parameters on each operating element.
 - b. Timing tests at two (2) or more points on time-current curve.
 - c. Pickup target and seal-in units.
 3. Special tests as required to check operation of restraint, directional and other elements per Manufacturer's instruction manual.
 4. Conduct tests to verify satisfactory performance of each control feature.
 5. Electrically confirm that CT and VT secondary circuits are intact.
- G. Instrument Transformers:
1. Electrical Tests – Current Transformers:
 - a. Electrically confirm that CT secondary circuits are intact.
 - b. Perform a ratio verification test of each current transformer. This shall be performed using the voltage method or current method in accordance with ANSI C57.13.1 (IEEE Guide for Field Testing of Relaying Current Transformers).
 - c. Perform insulation-resistance tests on current transformer secondary winding. Value of test voltage on secondary wiring shall be 1000 volts dc for one (1) minute. Do not perform this test with solid-state devices connected.
 2. Electrical Tests – Voltage Transformers:
 - a. Perform insulation-resistance tests on voltage transformers, winding-to-winding and windings-to-ground. Value of test voltage on secondary wiring shall be 500 volts dc for one (1) minute. Do not perform this test with solid-state devices connected.

- b. Electrically confirm proper secondary voltage.
 - c. Perform a dielectric withstand test on the primary windings with the secondary windings connected to ground. The dc dielectric voltage shall be in accordance with NETA Standard.
- H. Metering: Electrical Tests.
 - 1. Check calibration of meters at all cardinal points.
 - 2. Calibrate watt-hour meters to within Manufacturer's published accuracy.
 - 3. Verify all instrument multipliers.
 - 4. Electrical confirm that CT and VT secondary circuits are intact.
- I. Grounding Systems: Electrical Tests.
 - 1. Perform 3-point fall-of-potential test for all newly installed grounding systems.
 - a. At each grounding test well, Contractor shall separate ground rod and conductors and test grounding grid in all directions to verify resistance to ground for the grid.
 - 2. Perform point-to-point test to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.
- J. Ground-fault protection systems: Electrical Tests.
 - 1. Measure the system neutral to ground insulation resistance with the neutral disconnect link temporarily removed. Replace neutral disconnect link after testing. Notify equipment Owner or operator of any improper neutral to ground connections detected.
 - 2. Measure insulation resistance of the control wiring at 1000 volts dc for one (1) minute. If necessary, disconnect the solid state components.
 - 3. Perform pickup tests as follows using primary injection.
 - a. Verify the relay does not operate at 90% of the set pickup current.
 - b. Determine the pickup current of the relay and verify that this current is no greater than 125% of the setting. Pickup must not be greater than 1200 amperes.
 - 4. For summation type systems utilizing phase and neutral CT's, verify proper polarities by applying current to each phase-neutral CT pair. This test also applies to molded case breakers utilizing an external neutral CT.
 - a. Relay should operate when current direction is the same relative to polarity marks in the two CT's.
 - b. Relay should not operate when current direction is opposite relative to polarity marks in the two CT's.
 - 5. Measure time delay of the relay at 150% of pickup or greater.
 - 6. Verify the system is able to trip with control voltage at 55% of rated for systems utilizing ac control power and 80% of rated for systems utilizing dc control power.
 - 7. Verify operation of zone interlock systems by simultaneously injecting current at the interlocked relays and monitoring the control signals.

- K. AC motors: Electrical Tests - Induction Motors.
1. Perform insulation-resistance tests in accordance with ANSI/IEEE Standard 43.
 - a. Motors larger than 200 horsepower: Test duration shall be for 10 minutes with resistances tabulated at 30 seconds, one (1) minute, and 10 minutes. Calculate polarization index.
 - b. Motors 200 horsepower and less: Test duration shall be for one (1) minute with resistances tabulated at 30 and 60 seconds. Calculate the dielectric absorption ratio.
 2. Perform DC Overpotential Test (Hipot) on motors rated at 4000 volts and greater in accordance with ANSI/IEEE Standard 95.
 3. Perform insulation power-factor or dissipation-factor tests.
 4. Perform surge comparison tests.
 5. Perform insulation-resistance test on pedestal per Manufacturer's instructions.
 6. Perform insulation-resistance test on surge protection device in accordance with NETA Standard.
 7. Test motor starter in accordance with NETA Standard prior to re-energizing the motor.
 8. Check resistance temperature detector (RTD) circuits for conformance with Drawings. Check that metering or relaying devices using the RTD's are of the proper rating.
 9. Check that the motor space heater is operating.
 10. Perform a rotation test to insure proper shaft direction if the motor has been electrically disconnected.
 11. Measure running current and evaluate relative to load conditions and nameplate full-load amperes.
 12. Perform vibration tests:
 - a. Motors larger than 200 horsepower: Perform vibration base line test. Amplitude shall be plotted versus frequency.
 - b. Motors 200 horsepower and less: Perform vibration and amplitude test.
- L. Motor Control Centers/Motor Starters, Low Voltage: Electrical Tests.
1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with NETA Standard.
 2. Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground with starter closed and across each open pole for one minute. Test voltage shall be in accordance with Manufacturer's published data and NETA Standard whichever is more stringent.
 3. Measure insulation resistance of each control circuit-to-ground.
 4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Test duration shall be one (1) minute. For units with solid-state components, follow Manufacturer's recommendation.
 5. Test motor protection devices in accordance with Manufacturer's published data and NETA Standard whichever is more stringent.
 6. Test circuit breakers in accordance with NETA Standard.

7. Perform operational tests by initiating control devices.
- M. Surge Arresters, Surge Protection Devices: Electrical Tests.
1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, in accordance with NETA Standard.
 2. Perform an insulation-resistance test at voltage levels in accordance with NETA Standard.
 3. Test grounding connection in accordance with NETA Standard.
- N. Fiber-Optic Cables: Field Test.
1. Perform cable length measurement and detect fiber fractures or other defects through analysis of the backscattering signal with an optical time domain reflector (OTDR).
 - a. Perform testing on the reel (prior to pull) and after installation/termination.
 2. Perform a continuity test to detect splice fractures or other defects through analysis of the backscattering signal using the OTDR.
 3. Perform attenuation measurement of losses at each splice and connector for all types of fiber optic cables.
- O. Lighting
1. Turn on all lights after lamping them with new lamps take load readings of each circuit with lights on. Submit type-written results to the Austin Water. Results shall include panel board number and location, branch circuit number and load served, and amperage reading.
 2. Verify all photocells, time clocks, and lighting contactors are operationally correct and set to the correct time.
- P. Receptacles
1. Test all receptacles for proper connections and grounding. Use an approved plug-in tester (Woodhead 1750 or Hubbell 5200), or equal.
- Q. Exhaust Fans
1. Record SCFM and Amps for each exhaust fan installed under this project.
- R. Control circuits
1. Check all circuits for continuity, proper connection, and proper operations.
 2. Set all time delays relays and timers for the desired operations. Record the settings, indicating the relay or timer, its location, and the setting used. Verify all time settings reflect ENGINEER's direction.
- 3.02 PREPARATION
- A. Preparatory Work: Prior to the testing of any specific piece of equipment, the CONTRACTOR shall remove all shipping hardware and inspect for broken or missing parts and proper connections in accordance with the Manufacturer's instructions.
- B. Visual and Mechanical Inspection: Prior to any electrical testing CONTRACTOR shall perform a visual and Mechanical inspection as specified in the latest NETA standard.

3.03 TESTING AND INSPECTION

- A. All testing equipment shall have been factory calibrated within one-year of testing. Documentation of factory calibration shall be provided prior to testing.
- B. All tests, other than Low Voltage Systems and Equipment, shall be supervised by the CONTRACTOR. ENGINEER reserves the right to witness testing and calibration. CONTRACTOR shall give a two-week notice prior to all scheduled tests to the ENGINEER in writing.
- C. CONTRACTOR shall notify the ENGINEER of scheduled dates of electrical equipment installation completion. Equipment testing shall be coordinated by the CONTRACTOR, appropriate Manufacturer's Representative/s and with ENGINEER.
- D. CONTRACTOR shall perform electrical tests and calibration on specified equipment and as specified under this Section. The CONTRACTOR shall supply all resources, services, equipment, etc. required to perform all testing and calibration responsibilities.

3.04 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16110

RACEWAYS, FITTINGS AND SUPPORTS

PART 1 GENERAL

1.01 SUMMARY

- A. This section specifies raceways, fittings, and supports for all cables, conductors and electrical equipment. The CONTRACTOR shall furnish and install complete raceway systems in accordance with the following specifications.

1.02 RELATED REQUIREMENTS

- A. Work as called for on PLANS, or in this or other Specification Sections.

1.03 REFERENCES

- A. The publications listed below form a part of this specification to the extent referenced and shall apply as if written here in their entirety. The publications are referred to in the text by basic designation only.

NFPA 70	National Electrical Code (NEC)
NEMA 250	Enclosures for Electrical Equipment (1,000 volts maximum)
ANSI C80.1	Rigid Aluminum Conduit and Rigid Galvanized Steel Conduit
ANSI C80.4	Fittings and Supports for Conduit and Cable Assemblies
NEMA TC2	Electrical Plastic Tubing (EPT) and Conduit (EPC-40)
NEMA TC3	PVC Fittings for Use with Rigid PVC Conduit and Tubing.
UL7 514B	Fittings for Conduits and Outlet Boxes
UL 651	Schedule 40 Rigid PVC Conduit

1.04 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of Division 1.

1.05 OPERATION AND MAINTENANCE MANUALS

- A. Operations and Maintenance (O&M) Manuals are not required for materials covered under this Section.

PART 2 PRODUCTS

2.01 MATERIALS/CONSTRUCTION

A. Exposed-Outdoor and Non-Chemical Areas Above Ground Level

1. Rigid Aluminum Metal Conduit System

- a. Conduit run above ground shall be U.L. listed 99 % copper free rigid aluminum and meet the requirements of ANSI C40.5. Conduit pipe straps and hardware to be 316 stainless steel. Conduit shall be manufactured by Allied Company, or approved equal.
- b. Minimum above grade conduit size for all work shall be 3/4-inch.

2. Conduit Seals

- a. Conduit seals to be suitable for use in class-I, group B, C, and D, and class-II group F and G. Conduit seals shall also meet or exceed the following minimum requirements:
- b. Seal body, nipples and closures shall be 99% copper-free aluminum. Seal bodies shall be filled with 3M 2123 Re-Enterable Sealing Compound.
 - (i) Class 1, Division 1 areas shall be sealed per NEC requirements.
- c. Drain: Stainless steel
- d. Removable Nipples: 99% copper-free aluminum
- e. Conduit seals to be manufactured by Crouse-Hinds type EYS drain seals with specified options, or approved equal.

3. Conduit Hubs

- a. Conduit hubs shall be the grounding type, 99% copper-free aluminum (body, nipples, etc.), with integral insulated throat, and with solder-less grounding lugs as manufactured by Myers, or approved equal. Conduit hubs shall be furnished complete with rubber gasket.

4. Grounding Bushings

- a. Conduit grounding bushing shall be 99% copper-free aluminum (body, nipples, etc.), with integral insulated throat, and with solder-less grounding lugs as manufactured by Meyers type STAG, or approved equal.

5. Conduit Bodies

- a. All conduit bodies shall be 99% copper-free aluminum. Conduit bodies shall be manufactured by Crouse-Hinds Form 7, or approved equal.

6. Conduit Body Covers

- a. Conduit Body Covers shall be die cast aluminum with 316 stainless steel screws. Snap on covers are unacceptable. Supply separate gaskets with all covers.

7. 7. Conduit Unions

- a. Conduit unions shall be threaded, 99% copper-free aluminum. Conduit unions shall be manufactured by Crouse-Hinds type UNF or UNY, or approved equal.

8. Clamp Backs

- a. Single runs of conduit may be supported with cast aluminum clamp backs with stainless steel hardware and standoffs.

9. Conduit Straps

- a. All conduit straps shall be 316 Stainless Steel unless indicated differently by the plans and or specifications.

10. Liquid Tight Flexible Conduit

- a. Liquid tight flexible conduit shall be non-metallic (NM) type liquid tight flex for sizes $\frac{3}{4}$ " through 2". For sizes 2 $\frac{1}{2}$ " and larger provide standard seal tight flex with aluminum core, formed from PVC plastic. Provide aluminum or nonmetallic liquid tight fittings that are suitable for installation in temperature range between -20 degrees C to +60 degrees C (suitable for use outdoors and indoors). Liquid tight flexible conduit and fittings shall be as manufactured by "Electri-Flex" series NM type B-PVC, Thomas & Betts type LT-38P, or approved equal. $\frac{1}{2}$ " type NM flexible liquid tight conduit may be used for instruments having $\frac{1}{2}$ " threaded entry point.
- b. Liquid tight flexible conduit shall be used for connections to motors, field instruments, etc., and any equipment subject to vibration, and, where shown on the Drawings. Maximum length **to be 36" unless** otherwise noted on Drawings or approved by the OWNER or ENGINEER.

11. Electrical Equipment and Raceways Support Channels

- a. Electrical equipment and raceway support channels shall be fabricated with 316 stainless steel material manufactured by Unistrut Corporation series P-1000SS and P-1001SS, or approved equal. All fastening hardware, fittings, supports, base posts, clamps, framing system, etc. shall also be fabricated with 316 stainless steel. Manufacturer shall be Unistrut Corporation, or approved equal.

B. Exposed Chemical Areas

1. Schedule 80 PVC

- a. Conduit shall be Schedule 80 PVC, U.L. rated, No. 651, conforming to NEMA standard TC-2-75 and listed in conformity with Article 347 of the national Electrical Code (NEC). The conduit is to be manufactured by Carlon, or approved equal. Solvent weld shall be a type approved by the conduit Manufacturer.
- b. Minimum above grade conduit size for all work shall be 3/4-inch.

2. Conduit Hubs

- a. Conduit hubs shall be manufactured from fiberglass as manufactured by Champion, or approved equal. Conduit hubs shall be furnished complete with rubber gasket.

3. Conduit Bodies

- a. All conduit bodies shall be manufactured from PVC.

4. Conduit Body Covers

- a. Conduit Body Covers shall be PVC with 316 stainless steel screws. Conduit body covers shall be furnished complete with rubber gasket.

5. Clamp Backs

- a. Single runs of conduit may be supported with PVC or fiberglass clamp backs and standoffs with fiberglass hardware.

6. Conduit Straps
 - a. All conduit straps shall be fiberglass or PVC, unless indicated differently by the plans and or specifications.
 7. Liquid Tight Flexible Conduit
 - a. Liquid tight flexible conduit shall be non-metallic (NM) type liquid tight flex for sizes $\frac{3}{4}$ " through 2". For sizes 2 $\frac{1}{2}$ " and larger provide standard seal tight flex with aluminum core, formed from PVC plastic. Provide aluminum or nonmetallic liquid tight fittings that are suitable for installation in temperature range between -20 degrees C to +60 degrees C (suitable for use outdoors and indoors). Liquid tight flexible conduit and fittings shall be as manufactured by Electri-Flex series NM type B-PVC, Thomas & Betts type LT-38P, or approved equal. $\frac{1}{2}$ " type NM flexible liquid tight conduit may be used for instruments having $\frac{1}{2}$ " threaded entry point.
 - b. Liquid tight flexible conduit shall be used for connections to motors, field instruments, etc., and any equipment subject to vibration, and, where shown on the Drawings. Maximum length **to be 36" unless** otherwise noted on Drawings or approved by the OWNER or ENGINEER.
 8. Supporting Hardware and Brackets
 - a. All support channels shall be manufactured from fiberglass.
 - b. All fastening hardware shall be suitable for chemical area, or as approved by the ENGINEER/OWNER.
- C. Underground Conduit System in Duct Bank System and Conduit Concealed in Concrete
1. Schedule 40 PVC
 - a. Conduit run underground in duct bank system shall be Schedule 40 PVC, U.L. rated, No. 651, conforming to NEMA standard TC-2-75 and listed in conformity with Article 347 of the national Electrical Code (NEC). The conduit is to be manufactured by Carlon, or approved equal. Solvent weld shall be a type approved by the conduit Manufacturer.
 - b. Minimum conduit size for all underground work shall be 1-inch.
 2. PVC Coated Galvanized Rigid Steel Conduit
 - a. PVC coated RGS conduit shall be coated with a 40 mil exterior coating of PVC and a 2 mil urethane interior coating. The coating system shall be in compliance with ETL PVC-001. Refer to Part 3-Execution of this Section, and to details provided on the contract Drawings. PVC Coated Rigid Galvanized Steel conduit shall be Plasti-Bond REDH2OT or Perma-Cote coated conduit as manufactured by Rob Roy. A Manufacturer's installer certification shall be required for electricians installing the PVC coated RGS conduits.
 - b. Minimum conduit size for all underground work shall be 1-inch.

PART 3 EXECUTION

3.01 GENERAL

- A. Install electrical equipment and raceway system conduit in accordance with the recommendations of the Manufacturer, the requirements of the National Electrical Code, local codes, and the contract Drawings and these specifications.

- B. Use only persons skilled and licensed in the state of Texas to perform this type of work.

3.02 ERECTION, INSTALLATION, AND APPLICATION INSTRUCTIONS

A. Exposed-Outdoor and Non-Chemical Areas Above Ground Level

1. Utilize 316 stainless steel support channels to install raceways, and any other surface mounted electrical, instrumentation and control equipment. Refer to details shown on the contract Drawings.
2. All mounting hardware and straps shall be 316 stainless steel.
3. Run exposed conduit parallel or at right angles to building lines.
4. Secure conduits to all cabinets and boxes with specified hubs and bonding jumpers in such a manner that each system is electrically continuous throughout.
5. Install all conduits as a complete system before wiring is pulled in. Conduits shall be reamed and swabbed clean immediately before wiring is pulled in.
6. Cap conduits during construction to prevent entrance of dirt, trash, and water.
7. Equip conduit across structural joints, where structural movement is allowed with an O.Z./Gedney, or equal, 99 % aluminum expansion fittings of that conduit size.
8. Conduit nipples shall have two independent sets of threads. Running threads shall not be used. Where conditions require joining two fixed conduits into a continuous run, a conduit union shall be used.
9. Coat all conduit threads with LOCTITE LB 8014 Food Grade Anti-Seize or approved equal.
10. Maintain 6-inch clearance between conduit and piping and 12-inch clearance between conduit and heat sources such as flues, steam pipes and heating appliances.
11. Arrange conduits to maintain headroom and present a neat appearance.
12. Conduits run above ground shall be supported at least every 10-feet and once in every change in direction and at the end of each straight run terminating in an enclosure and within three feet of every junction box.
13. Secure conduit runs firmly to specified support channels by stainless steel conduit straps or by hangers, as required.
14. Rigid conduit joints to be cut square, threaded, reamed smooth and drawn up tight. Bends or offsets to be made with standard conduit ells. Make field bends with an approved bender or hickey or hub type conduit fittings. Conduit shall contain no more than the equivalent or three (3) 90-degree bends between outlets or fittings.

B. Exposed Chemical Areas

1. Run exposed conduit parallel or at right angles to building lines.
2. Secure conduits to all cabinets and boxes with specified hubs and bonding jumpers in such a manner that each system is electrically continuous throughout.
3. Install all conduits as a complete system before wiring is pulled in. Conduits shall be reamed and swabbed clean immediately before wiring is pulled in.
4. Cap conduits during construction to prevent entrance of dirt, trash, and water.
5. Equip conduit across structural joints, where structural movement is allowed with PVC expansion fittings of that conduit size.

6. Maintain 6-inch clearance between conduit and piping and 12-inch clearance between conduit and heat sources such as flues, steam pipes and heating appliances.
 7. Arrange conduits to maintain headroom and present a neat appearance.
 8. Conduits run above ground shall be supported per NEC requirements based on conduit size, at every change in direction and at the end of each straight run terminating in an enclosure and within 12-inches of every junction box.
 9. Secure conduit runs firmly to specified support channels by fiberglass conduit straps or by hangers, as required.
 10. Conduit shall contain no more than the equivalent or three (3) 90-degree bends between outlets or fittings.
 11. NEC approved bender is required for bending PVC conduit. Open flame is not allowed.
- C. Underground Conduit System in Duct Bank System and Conduit Concealed in Concrete
1. Install Schedule 40 PVC conduit underground in steel reinforced duct banks changing to PVC coated rigid galvanized steel conduit at the final factory 90-degree bend, transitioning from underground to the above ground conduit system.
 2. The transition from PVC coated RGS to aluminum rigid shall be made at a minimum of six (6) inches above finished slab and/or housekeeping pad. Duct bank concrete shall extend six (6) inches above finished grade at all outdoor locations.
 3. Duct banks and/or conduit banks shall be continuously reinforced along the entire length utilizing No. 4 stirrups at 1'-6" spacing and No. 5 longitudinal bars at all four corners, at a minimum. Provide 1'-6" overlap splices on all longitudinal bars.
 4. Conduit support chairs shall be spaced at 5'-0" minimum spacing.
 5. Duct banks shall be encased in red concrete to its final destination even when routed under building/structure, concrete floor slab, and/or equipment concrete/housekeeping concrete pad. Rebar shall be kept a minimum of two (2) inches off of the ground to allow complete concrete coverage. Concrete shall be per cast-in-place concrete specification, class F. When there is no cast in place concrete spec, the concrete shall be 4000 psi. A red add mixture, HBS #120 Conduit Red as manufactured by ChemSystems, Inc., or equal, shall be added to the concrete at a minimum of 12 pounds per cubic yard of concrete. Forms shall be used unless the trench wall is stable enough to support the concrete.
 - a. All form boards shall be removed after concrete has been poured and set.
 - b. Stay-form may be used in lieu of form boards. Minimum clearance between form and reinforcing steel is maintained and the Stay-form does not tie to the duct bank rebar.
 6. Cap conduits during construction to prevent entrance of dirt, trash, and water.
 7. Provide a minimum of 2-inches separation utilizing Plastic conduit chairs between conduits installed in concrete duct bank. Spacing may be less at panel boards, pull or junction boxes or other locations where the conduits have to be grouped.
 8. The minimum depth of a duct bank is twenty-four (24) inches to the top of the Concrete.
 9. Duct bank conduits shall have a minimum of three (3) inches per 100-feet slope from the high point toward the manholes.

10. All underground conduit joints shall be waterproofed in accordance with the Manufacturer's recommendations
11. Backfilling shall be done in such a manner that voids will be minimized. Compact backfill so that it is the same density as the surrounding soil. Excess soil shall be piled on top and shall be well tamped. All rock and debris greater than one (1) inch in size shall be removed from the site.
12. Conduits joints to be staggered a minimum of six (6) inches.
13. Where a duct bank penetrates or turns up next to a structure, dowel rebar a minimum of four (4) inches into the structure at the point of connection/intersection tying the steel reinforcing of the duct bank to the structure at a minimum of four locations.
14. All duct banks shall be placed under building slab (not in building slab) with longitudinal duct bank steel reinforcement tied to building slab steel reinforcement with an 18-inch overlap.
15. Conduits shall penetrate building slab at 90-degrees and shall run in duct banks under building slab and not run parallel though building slabs.
16. NEC approved bender is required for bending PVC conduit. Open flame is not allowed.
17. Polyethylene Warning Tape
 - a. Warning tape shall be red metal detectable polyester, 6-in minimum width.
 - b. Warning tape legend shall read: "CAUTION: BURIED ELECTRIC LINE BELOW".
 - c. Contractor shall place tape 6" below grade on all buried electrical duct banks or as shown on the PLANS.
18. Hand holes and Manholes
 - a. All hand holes and manholes (cast-in-place and pre-cast) shall have a solid bottom unless otherwise noted on the drawings.
 - b. Hand holes are not required to be grounded unless otherwise noted on the drawings.

D. Conduit Penetrations:

1. Use 3M No. 51 20mil corrosion tape to protect raceways for penetrations through walls, floors, and block outs and grout once work is complete. The tape should extend six (6) inches beyond the walls or floors.
2. Link-Seal modular seals shall be used for all subgrade conduit penetrations.
3. PVC pipe shall be used for all pour-in-place concrete conduit penetrations.
4. Penetrations made through fire-rated walls or floors of buildings shall be sealed with appropriate fire-stop material/product.
5. For all penetrations into conditioned space from the exterior or from the thickening area must include Polywater FST-250 duct sealant applied in an EYS fitting.

E. Miscellaneous

1. Seal empty spare conduits (at above ground stub-ups) with an all-solid aluminum washer sized to the trade size (outer diameter) of the conduits.
2. Seal and pack/fill ends of each conduit with fire-retardant and waterproof conduit/duct sealant as manufactured by Nelson Flameseal or approved equal.

3. In all sealing fittings, utilize 3M Company 2123 Re-Enterable Sealing Compound to seal around and between each conductor and associated fitting body.

3.03 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16140
WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish and install all necessary wiring devices at the locations indicated on the Plans and elsewhere as required.

1.02 RELATED REQUIREMENTS

- A. Work as called for on PLANS, or in this or other Specification Sections.

1.03 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of Division 1, "Submittals".
- B. Operations and Maintenance (O&M) Manuals shall be made in accordance with the requirements of Division 1.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS (NOT USED)

2.02 MATERIALS/CONSTRUCTION

- A. Light Switches
 - 1. Specification grade, 20 amp, 120/277 volts. Hubbell 1221-I through 1224-I (single pole through four-way respectively). Ivory operating handle: Equals by Bryant, General Electric, Pass and Seymour are acceptable.
 - 2. Switch cover plates shall be Die Cast Aluminum, 99% copper-free, "Crouse Hinds" DS185, or approved equal, or as indicated on the Plans.
 - 3. Mount in boxes as specified in Division 16.
 - 4. All mounting hardware is to be 316 stainless steel.
- B. Receptacles
 - 1. Standard:
 - a. Hubbell No. 5362-I, or approved equal by Bryant, General Electric, Pass and Seymour. Duplex, 3-wire, polarized grounding type, rated 20 amp, 125 volt, 60 Hertz.
 - 2. Ground Fault:
 - a. Weather resistant, Hubbell No. GFTR20IU, or approved equal by Bryant, General Electric, Pass and Seymour.
 - 3. Mount in boxes as specified in Division 16.

- C. Receptacle Covers
 - 1. Outdoor receptacle covers shall be While-In-Use covers per NEC.
 - 2. Indoor receptacle cover plates shall be Die Cast Aluminum, 99% copper-free, manufactured by "Crouse-Hinds" WLRS (single cover) and WLRD (duplex cover), or approved equal.

PART 3 EXECUTION

3.01 ERECTION, INSTALLATION, AND APPLICATION INSTRUCTIONS

- A. Installation
 - 1. Switch and receptacle elevations shall be as indicated in Division 16.
 - 2. Indoor and outdoor boxes shall be grounded per Division 16 Grounding.

3.02 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16150

NEMA FRAME INDUCTION MOTORS, 600V AND BELOW

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Provide electric motors, accessories, and appurtenances complete and operable, in conformance with the individual driven equipment specifications and other sections of the Contract Documents.
- B. The provisions of this Section shall apply to all low voltage NEMA Frame AC squirrel cage induction motors, except as indicated otherwise. This specification is to be used for all motors that are not specifically specified in detail in an equipment specification. If an equipment specification has detailed requirement for a motor, those requirements will supersede the requirements of this specification.

1.02 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of Division 1, Section 16010 and as specified herein.
- B. Submittals shall also contain information on related equipment to be furnished under this Specification. Incomplete submittals not containing the required information on the related equipment will be returned unreviewed.
- C. Submittals for motors that are supplied by an equipment manufacturer shall be included with the equipment submittal.
- D. The following information shall be submitted with the motor drawings for review.
 - 1. Name of Drive
 - 2. Horsepower of Motor
 - 3. Phase
 - 4. Efficiency at 1/2, 3/4, Full Load
 - 5. Voltage
 - 6. Power Factor at 1/2, 3/4, Full Load
 - 7. Speed
 - 8. NEMA Design Starting Torque
 - 9. NEMA Frame and Dimensions
 - 10. Full Load Current
 - 11. Locked Rotor Current
 - 12. Insulation Class
 - 13. Temperature Rise at 1.15 SF
 - 14. Enclosure
 - 15. Bearing life design
 - 16. Special features (i.e., space heaters, RTDs, oversize conduit box and corrosion resistant features).

17. Nameplate Drawing with Information, as specified, shown.

- E. Suppliers of fractional horsepower motors below frame 143T will not be required to submit operational characteristics.
- F. Factory Tests. Submittals shall be made for factory tests as specified above.
- G. Field Test Reports. Submittals shall be made for field tests specified herein.
- H. Operation and Maintenance Manuals.
 - 1. Operation and maintenance manuals shall include the following information:
 - a. Manufacturer's contact address and telephone number for parts and service.
 - b. Instruction books and/or leaflets
 - c. Recommended renewal parts list
 - d. Record Documents for the information required by the submitted motor information above.

1.03 REFERENCE STANDARDS

- A. Motors shall be designed, built, and tested in accordance with the latest revision of the following standards:
 - 1. National Electrical Manufacturers Association Inc. (NEMA)
 - a. NEMA MG1 – Motors and Generators.
 - b. NEMA MG2 – Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators.
 - c. NEMA MG3 – Sound Level Prediction for Installed Rotating Electrical Machines.
 - 2. National Fire Protection Association (NFPA)
 - a. NFPA-70 – National Electrical Code.
 - 3. Underwriters Laboratories, Inc. (UL)
 - a. UL-1004 – Electric Motors.
 - 4. Institute of Electrical and Electronics Engineers, Inc. (IEEE)
 - a. IEEE Std 1 – General Principles for Temperature Limits in the Rating of Electric Equipment.
 - b. IEEE Std 43 – Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
 - c. IEEE Std 85 – Test Procedures for Airborne Sound Measurements on Rotating Electric Machinery.
 - d. IEEE Std 112 – Standard Test Procedure for Polyphase Induction Motors and Generators.
 - e. IEEE Std 275 – Recommended Practice for Thermal Evaluation of Insulation Systems for AC Electric Machinery Employing Form-wound Pre-insulated Stator Coils, Machines Rated 6,900 V and Below.
 - f. IEEE Std 429 – Standard Test Procedure for the Evaluation of Sealed Insulation Systems for AC Electric Machinery Employing Form-wound Stator Coils.
 - g. IEEE Std 1349 – Guide for the Application of Electric Motors in Class 1, Div 2 Hazardous Locations.

- 5. Anti-Friction Bearing Manufacturer's Association Inc. (AFBMA):
 - a. AFBMA-9 & 11 – Load Ratings and Fatigue Life for Roller Bearings.

- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 DEFINITIONS

- A. Motors specified herein are three-phase, squirrel cage induction type for ½ HP and above, and single phase for less than ½ HP, except as specifically specified elsewhere in these Specifications.
- B. Exclusion. Any self-contained portable appliance, which includes the motor with or without control that is specifically referred to, by catalog number on the Drawings or in other sections of the Specifications (more specifically fan coil unit motors, exhaust fan motors, unit heater motors, and blower ventilation motors) are not covered by this Section of the Specifications.
- C. The word "Drive" shall be construed to mean the driven equipment, i.e. pump, hoist, fan, compressor, or adjustable frequency drive connected with the motor.
- D. If there is inconsistency of size on different Drawing sheets or between Drawings and other sections of Specifications, relating to the horsepower designation, then the larger size shall be required.

1.05 QUALITY ASSURANCE

- A. Motor Compatibility. The CONTRACTOR shall be satisfied that the motor included with the drive is compatible with driven equipment and complies with these Specifications. In the event that the motors described in these Specifications cannot be applied to the application or equipment offered, the CONTRACTOR may submit an exception, stating clearly the deviations and the reasons for such deviations. The acceptance or rejection of such deviations shall be at the sole discretion of the OWNER/ENGINEER.
- B. When motors are furnished with driven equipment, the driven equipment supplier shall be responsible for mounting the motor and driven equipment as a complete unit, correctly aligned and coupled with the coupling or sheave specified on the driven equipment data sheet, and for designing vibration, special, or unbalanced forces resulting from equipment operation.
- C. Motors manufactured more than twenty four (24) months prior to the date of this Contract will not be acceptable.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Protect equipment during shipment, handling, and storage by suitable complete enclosures. Protect equipment from exposure to the elements and keep thoroughly dry.
- B. Protect painted surfaces against impact, abrasion, discoloration, and other damage. Repaint damaged painted surfaces to the satisfaction of the OWNER/ENGINEER.

- C. Equipment shall not be stored onsite without written approval of the OWNER/ENGINEER. Equipment must be installed in its permanent location shown on the Drawings within seven (7) calendar days of arriving onsite. If the equipment cannot be installed within seven (7) calendar days, the equipment shall not be delivered to the site, but stored offsite, in an air conditioned, bonded, warehouse of the CONTRACTOR's choice and at the CONTRACTOR's expense, until such time that the site is ready for permanent installation of the equipment.
- D. Where space heaters are provided in motors, provide temporary electrical power and operate space heaters, during jobsite storage and after motors are installed in permanent location, until equipment is placed in service.
- E. The motor shaft shall be rotated on a monthly basis, if such is recommended or required by the motor Manufacturer, the date recorded, and copies of the record provided to the OWNER/ENGINEER and the Manufacturer. The Manufacturer shall confirm receipt of the rotation record.

1.07 WARRANTY

- A. The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for a minimum of 2 years beginning after completion of the initial operation period as defined in the Contract Documents. Within such period of warranty the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Refer to Division 11 specifications for acceptable manufacturers.
- B. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.02 GENERAL REQUIREMENTS

- A. Each motor provided shall have an Identification Tag Number, conforming to the numbering system and equipment name shown on the Drawings.
- B. Specific motor data such as HP, RPM, enclosure type, etc., is specified under the detailed specification for the mechanical equipment with which the motor is supplied.
- C. The motor Manufacturer's nameplates shall be engraved or embossed on stainless steel and fastened to the motor frame with stainless steel screws or drive pins. Nameplates shall indicate clearly all of the items of information enumerated in NEMA Standard MG1, as applicable, including but not limited to the following information:
 - 1. Horsepower (output).
 - 2. RPM at full load.
 - 3. Time rating.

4. Frequency.
 5. Number of phases.
 6. Model number.
 7. Rated voltage.
 8. Service factor.
 9. Full load amps.
 10. Insulation class.
 11. NEMA design letter.
 12. NEMA code letter.
 13. Temperature Rise.
 14. NEMA Frame size.
 15. Date of manufacture.
 16. Thermal protection (if supplied).
- D. Where frequent starting occurs, the design for frequent starting duty shall be equal to the duty service required by the driven equipment.
- E. Altitude: Under 3300 FT. For applications above 3300 FT, motors shall be specifically designed and certified for operation at the specific altitude.
- F. Motors shall have sufficient horsepower and torque capacity to drive the equipment without overloading under all conditions, without exceeding the nameplate rating of the motor and without use of the service factor.
- G. Motors shall have a breather drain in each end bracket of the TEFC motor enclosure. Stainless steel automatic breather drains shall be provided in the lowest part of both end brackets to allow drainage of condensation.
- H. Motors shall be slide rail mounted for all belt or chain-driven applications.
- I. Air inlets and outlets shall be protected by vermin-proof, corrosion resistant louvers. The air inlets shall be located on end or side as required by the application.
- J. Motors shall have an oversized, gasketed, cast iron conduit box, field adjustable in 90-degree increments unless the box contains equipment, diagonally split with tapped NPT threaded conduit entrance hole, and shall exceed the minimum volumes defined in IEEE 841-2001. Neoprene conduit box cover gasket and neoprene lead seal gasket with flexible nipples to ensure the seal is maintained as the leads are moved shall be furnished. Provision for grounding shall be provided in the conduit box utilizing a mounted clamp-type lug.
- K. Provide separate accessory lead conduit boxes. Minimum size entrance hub shall be $\frac{3}{4}$ "C. Resistance temperature detector leads shall not occupy the same box with any other type of power or monitoring leads.
- L. Motor frames, end brackets, and conduit box shall be of cast-iron.
- M. Provide lifting lugs on the motor frame.

- N. Motors shall be NEMA Design B standard, unless otherwise specified.
- O. Service factor shall be 1.15 for all motors when operated on sine wave power, and 1.0 service factor when operated on PWM inverter power.
- P. Motors shall meet NEMA MG 1 (NEMA Premium) efficiencies. If the motor horsepower, or speed, is not covered in the Tables herein, provide the Manufacturer's "Energy Efficient" type.
- Q. All motors shall be continuous time rated suitable for operation in a 40 degrees C ambient, unless specified otherwise.
- R. Unless otherwise indicated or specified, motors shall be totally enclosed fan cooled (TEFC), for all applications. See the mechanical specifications for pumps and other equipment that require additional enclosure requirements.
- S. TEFC Motors shall have corrosion resistant enclosures, epoxy paint, corrosion resistant fittings and stainless steel or aluminum nameplates similar to "Mill and Chemical", "Corro- Duty", "Chemical Processing" motors, or equal.
- T. The motors are to be bi-directional. If the fan must be uni-directional, it shall be the motor Manufacturer's responsibility to obtain the direction required from the drive Manufacturer.
- U. Guards
 - 1. Exposed moving parts shall be provided with guards in accordance with the requirements of OSHA. Guards shall be fabricated of flattened expanded metal screen, 3/4-inch No. 10, to provide visual inspection of moving parts without removal of the guard.
 - 2. Guards shall be galvanized after fabrication and shall be designed to be readily removable to facilitate maintenance of moving parts. Windows shall be provided in the guard for access to the lubricating fittings.

2.03 FRACTIONAL HORSEPOWER MOTORS – LESS THAN ½ HP

- A. Motor voltage shall be single phase, 115 V, 60 Hz, unless otherwise shown on the Drawings.
- B. Enclosures shall be TEFC or TENV.
- C. Motors shall have a built-in manual or automatic reset thermal protector, or an integrally mounted, enclosed manual reset, motor overload switch.

2.04 MOTORS ½ HP AND LARGER

- A. Motor voltage shall be single voltage, as shown on the Drawings, and in compliance with IEEE 841.

- B. Motors shall have NEMA standard Class "F" insulation with Class "B" temperature rise above 40 Deg C ambient on a continuous operation or intermittent duty at nameplate horsepower.
- C. Motors shall have non-hygroscopic encapsulated windings. Motor leads shall be Class F rated, with permanent identification.
- D. Motor rotors, exceeding Code G, shall be fabricated copper. Rotors on frames 213T and above shall be keyed to the shaft and rotating assembly dynamically balanced. Balance weights, if required, shall be secured to the rotor resistance ring by peened integrally cast sprues. Machine screws and nuts are not acceptable, The rotating assembly shall be coated with a corrosion-resistant epoxy.
- E. Motors larger than 15 HP shall have a locked rotor inrush kVA not exceeding Code G (6.29 KVA/HP).
- F. Motors shall meet or exceed the efficiencies in NEMA MG-1 at the approximate nameplate current values at 460 volts.
- G. The motor insulation system for motors controlled with VFD's shall have full capability to handle the common mode voltage conditions imposed by the VFD. Motor insulation system shall conform to all of the requirements of the latest version of NEMA MG1, Part 31 for peak voltage withstand capability.
- H. The critical speed of the shaft and rotor assembly shall exceed the operating speed by a minimum of 10 percent.
- I. The no-load sound pressure level, based on the A-weighted scale at 3 feet, when measured in accordance with IEEE Std. 85 shall not exceed 85dBA.
- J. Vibration limits shall not exceed 0.2-in/sec at any frequency.
- K. Motors shall have a minimum of two brass grounding pads on each motor frame.
- L. Bearings
 - 1. Motors 1/2 through 5 HP shall have permanently lubricated sealed antifriction ball-bearings with L10 lifetime of 50,000 HRS.
 - 2. Motors 5 through 50 HP, for direct connected or coupled applications, shall have oil or grease-lubricated antifriction ball-bearings with L10 lifetime of 100,000 HRS.
 - 3. Motors 50 HP and larger shall have oil or grease-lubricated antifriction ball-bearings with L10 lifetime of 50,000 HRS.
 - 4. Vertical motor thrust and guide bearings shall conform to AFBMA standards and shall have L10 lifetime ratings as specified for ball-bearings of the same horsepower range. Down thrust information shall be provided to the motor manufacturer by the equipment supplier.
 - 5. Anti-friction motor bearings shall be designed to be regreasable and initially shall be filled with grease suitable to ambient temperature of 40 degrees C.
 - 6. Grease lubricated bearings, except those specified to be factory sealed and lubricated, shall be fitted with easily accessible grease supply, flush, drain and relief

fittings. Extension tubes shall be used when necessary. Grease supply fittings shall be standard hydraulic type as manufactured by the Alemite Division of the Stewart Warner Corporation.

7. Sealed bearings shall be contact seal (lip) or non contact labyrinth type.

M. Space Heaters

1. Space heaters shall be supplied with all 3 phase motors and shall conform to the following:
 - a. Heaters shall be of the cartridge or flexible wrap around type installed within the motor enclosure adjacent to core iron. Heaters shall be rated for 120 V, single phase with wattage as required. The heater wattage and voltage shall be embossed on the motor nameplate. Power leads for heaters shall be brought out at the motor accessory lead junction box.

N. Stator Temperature Detection

1. Winding temperature detectors of the bi-metallic switch type shall be provided for all motors above 75 hp through 150 hp, and for all motors through 150 hp controlled by adjustable frequency drives. Provide the detectors factory installed, embedded, with leads terminating in the main conduit box. Device shall protect the motor against damage from overheating caused by single phasing, overload, high ambient temperature, abnormal voltage, locked rotor, frequent starts or ventilation failure. The switch shall have normally closed contacts. Not less than three detectors shall be furnished with each motor.
2. Winding temperature detectors of the resistance-type temperature detector type shall be provided for all motors larger than 150 hp. Each detector shall be of the 100-ohm platinum type. Each phase winding shall have two detectors for a total of six. Install the detectors between stator coils where the highest temperature will occur. One set in each phase shall be operational and one set spare.
3. Wire all temperature detectors to separate terminal box on the motor. Terminal box shall be weatherproof NEMA 4 with barrier-type screw-post terminals.

O. Bearing Temperature Detection

1. Where specified elsewhere or shown on the Drawings, bearing temperature detectors of the resistance-type temperature detector type (RTD) shall be provided in each pump or driven equipment motor bearing for all motors larger than 350 hp. For vertical motors, provide a detector in each thrust bearing and lower radial guide bearing. Each detector shall be of the 100-ohm platinum type.

- P. For motors utilizing power factor correction capacitors connected to the starter output terminals, the motor overload elements or trip settings shall be adjusted downwards to reflect the reduction in line current resulting from power factor correction. Power factor correction capacitors shall not be applied to the load side of adjustable frequency drives.

2.05 FACTORY TESTING

- A. Motors rated 300 HP and larger shall be standard motor tested. Except where specific testing or witnessed shop tests are required by the specifications for driven equipment, factory test reports may be copies of routine test reports of electrically duplicate motors.

Test report shall indicate test procedure and instrumentation used to measure and record data. Test report shall be certified by the motor manufacturer's test personnel and be submitted to the ENGINEER for approval.

- B. When specified under the detailed mechanical section, provide a complete test per NEMA MG1 and IEEE Standard 112 consisting of the following:
 - 1. Full Load Heat Run
 - 2. Temperature Test (Actual loading method)
 - 3. Performance Test
 - 4. Locked Rotor
 - 5. No Load Saturation
 - 6. Speed Torque
 - 7. Winding Resistance (A 118 and 43)
 - 8. High Potential
 - 9. Noise Test (A 85)
- C. Balance and vibration shall meet NEMA standards MG1-12.05 and MG1-12.06.

PART 3 EXECUTION

3.01 INSTALLATION

- A. The CONTRACTOR shall install motors in accordance with the manufacturer's instructions.
- B. Make a visual and mechanical inspection.
- C. Check for physical damage.
- D. Compare equipment nameplate information with single line diagram and report any discrepancies.
- E. Inspect for proper mounting, grounding, connection, and lubrication.
- F. Inspect each motor for the proper installation, rated voltage, phase and speed.
- G. Check for proper phase and ground connections, Check to see that multi-voltage motors are connected for the proper voltage.

3.02 TESTS

- A. Test for proper rotation prior to connection to the driven equipment.
- B. Test the insulation (megger test) of all new motors, 10 hp and above, in accordance with NEMA MG-1. Test voltage shall be 1000 VAC plus twice the rated voltage of the motor.
- C. For motors 300 hp and larger, test duration shall be for 10 minutes with resistances tabulated every 15 seconds for the first minute and then every minute for the next ten. The megohm rating at the end of the 10 minutes shall be at least twice as high as the 1 minute reading. Dielectric absorption ratio and polarization index shall be calculated.

- D. Perform a rotation test to ensure proper shaft direction.
- E. Where a motor is inverter fed, the direction of rotation shall be checked by momentary application of voltage to the motor, to confirm that the phase sequence is the same as the incoming power to the inverter.
- F. Measure running current and evaluate relative to load conditions and nameplate full load amperes.
- G. Inspect for unusual mechanical or electrical noise or signs of overheating during initial test run.
- H. Monitor motors during startup and commissioning to record operating amps, voltage and operating vibration levels.
- I. Submit test report and all recorded field data. Submit copies of the raw data recorded in the field, signed by the person recording the data, and typewritten reports certified by the CONTRACTOR. The motors will not be accepted until the reports are submitted and approved.

3.03 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

PART 4 TABLES OF MOTOR EFFICIENCIES

OPEN DRIP-PROOF (ODP)								
FULL-LOAD EFFICIENCIES OF ENERGY EFFICIENT MOTORS								
OPEN MOTORS								
	2 POLE (3600 RPM)		4 POLE (1800 RPM)		6 POLE (1200 RPM)		8 POLE (900 RPM)	
HP	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.
1.0	--	--	82.5	80.0	80.0	77.0	74.0	70.0
1.5	82.5	80.0	84.0	81.5	84.0	81.5	75.5	72.0
2.0	84.0	81.5	84.0	81.5	85.5	82.5	85.5	82.5
3.0	84.0	81.5	86.5	84.0	86.5	84.0	86.5	84.0
5.0	85.5	82.5	87.5	85.5	87.5	85.5	87.5	85.5
7.5	87.5	85.5	88.5	86.5	88.5	86.5	88.5	86.5
10.0	88.5	86.5	89.5	87.5	90.2	88.5	89.5	87.5
15.0	89.5	87.5	91.0	89.5	90.2	88.5	89.5	87.5
20.0	90.2	88.5	91.0	89.5	91.0	89.5	90.2	88.5
25.0	91.0	89.5	91.7	90.2	91.7	90.2	90.2	88.5
30.0	91.0	89.5	92.4	91.0	92.4	91.0	91.0	89.5
40.0	91.7	90.2	93.0	91.7	93.0	91.7	91.0	89.5
50.0	92.4	91.0	93.0	91.7	93.0	91.7	91.7	90.2
60.0	93.0	91.7	93.6	92.4	93.6	92.4	92.4	91.0
75.0	93.0	91.7	94.1	93.0	93.6	92.4	93.6	92.4
100.0	93.0	91.7	94.1	93.0	94.1	93.0	93.6	92.4
125.0	93.6	92.4	94.5	93.6	94.1	93.0	93.6	92.4
150.0	93.6	92.4	95.0	94.1	94.5	93.6	93.6	92.4
200.0	94.5	93.6	95.0	94.1	94.5	93.6	93.6	92.4
250.0	94.5	93.6	95.4	94.5	95.4	94.5	94.5	93.6
300.0	95.0	94.1	95.4	94.5	95.4	94.5	--	--
350.0	95.0	94.1	95.4	94.5	95.4	94.5	--	--
400.0	95.4	94.5	95.4	94.5	--	--	--	--
450.0	95.8	95.0	95.8	95.0	--	--	--	--
500.0	95.8	95.0	95.8	95.0	--	--	--	--

TOTALLY ENCLOSED - FAN COOLED (TEFC)								
ENCLOSED MOTORS								
	2 POLE (3600 RPM)		4 POLE (1800 RPM)		6 POLE (1200 RPM)		8 POLE (900 RPM)	
HP	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.	Nom. Effic.	Min. Effic.
1.0	75.5	72.0	82.5	80.0	80.0	77.0	74.0	70.0
1.5	82.5	80.0	84.0	81.5	85.5	82.5	77.0	74.0
2.0	84.0	81.5	84.0	81.5	86.5	84.0	82.5	80.0
3.0	85.5	82.5	87.5	85.5	87.5	85.5	84.0	81.5
5.0	87.5	85.5	87.5	85.5	87.5	85.5	85.5	82.5
7.5	88.5	86.5	89.5	87.5	89.5	87.5	85.5	82.5
10.0	89.5	87.5	89.5	87.5	89.5	87.5	88.5	86.5
15.0	90.2	88.5	91.0	89.5	90.2	88.5	88.5	86.5
20.0	90.2	88.5	91.0	89.5	90.2	88.5	89.5	87.5
25.0	91.0	89.5	92.4	91.0	91.7	90.2	89.5	87.5
30.0	91.0	89.5	92.4	91.0	91.7	90.2	91.0	89.5
40.0	91.7	90.2	93.0	91.7	93.0	91.7	91.0	89.5
50.0	92.4	91.0	93.0	91.7	93.0	91.7	91.7	90.2
60.0	93.0	91.7	93.6	92.4	93.6	92.4	91.7	90.2
75.0	93.0	91.7	94.1	93.0	93.6	92.4	93.0	91.7
100.0	93.6	92.4	94.5	93.6	94.1	93.0	93.0	91.7
125.0	94.5	93.6	94.5	93.6	94.1	93.0	93.6	92.4
150.0	94.5	93.6	95.0	94.1	95.0	94.1	93.6	92.4
200.0	95.0	94.1	95.0	94.1	95.0	94.1	94.1	93.0
250.0	95.4	94.5	95.0	94.1	95.0	94.1	94.5	93.6
300.0	95.4	94.5	95.4	94.5	95.0	94.1	--	--
350.0	95.4	94.5	95.4	94.5	95.0	94.1	--	--
400.0	95.4	94.5	95.4	94.5	--	--	--	--
450.0	95.4	94.5	95.4	94.5	--	--	--	--
500.0	95.4	94.5	95.8	95.0	--	--	--	--

END OF SECTION

SECTION 16191

MISCELLANEOUS EQUIPMENT

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish and install miscellaneous equipment as specified herein, together with appurtenances, complete and operable, as shown on the Drawings and as specified herein.
- B. The items of equipment are for individual applications as separately enclosed items. Submittals made under this Section, for components and electrical items specified under other Sections, will be returned unreviewed.

1.02 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of Division 1, Division 16 and as specified herein.
- B. Submittals shall also contain information on related equipment, with schematics and logic shown on the Drawings, to be furnished under this Specification. Incomplete submittals not containing the required information on the related equipment will be returned unreviewed. Submittals for equipment specified in other Sections, shall not be submitted under this Section. Such submittals will also be returned unreviewed.
- C. The original equipment Manufacturer shall create all equipment shop drawings, including all wiring diagrams, in the Manufacturer's engineering department. All equipment shop drawings shall bear the original equipment Manufacturer's MCC logo, drawing file numbers, and shall be maintained on file in the equipment Manufacturer's archive file system. Photocopies of the ENGINEER's ladder schematics are unacceptable as shop drawings.
- D. Submit to the OWNER/ENGINEER, shop drawings and product data, for the following:
 - 1. Equipment outline drawings showing elevation and plan views, dimensions, weight, shipping splits and metering layouts. Indicate all options, special features, ratings and deviations from the Specifications.
 - 2. Conduit entrance drawings, including floor penetrations.
 - 3. Bus arrangement drawings.
 - 4. Unit summary tables showing detailed equipment description and nameplate data for each item.
 - 5. Product data sheets and catalog numbers for overcurrent protective devices, motor starters, control relays, control stations, meters, pilot lights, etc. List all options, trip adjustments and accessories furnished specifically for this project.
 - 6. Provide control systems engineering to produce custom unit elementary drawings showing interwiring and interlocking between units and to remotely mounted devices. Show wire and terminal numbers. Indicate special identifications for electrical devices per the Drawings.

7. Master drawing index
8. Front view elevation
9. Floor plan
10. Top view
11. Single line
12. Schematic diagram
13. Nameplate schedule
14. UL Listing
15. Component list with application name of each detailed component.
16. Conduit entry/exit locations
17. Assembly ratings including:
 - a. Short-circuit rating
 - b. Voltage
 - c. Continuous current
18. Major component ratings including:
 - a. Voltage
 - b. Continuous current
 - c. Interrupting ratings
19. Descriptive bulletins
20. Product data sheets.
21. Cable terminal sizes.
22. Key interlock scheme drawing and sequence of operations
23. Busway connection.
24. Instruction and renewal parts books.
25. Itemized list of spare parts furnished specifically for this project, including quantities, description and part numbers.

E. Factory Tests. Submittals shall be made for factory tests specified herein.

F. Field Test Reports. Submittals shall be made for field tests specified herein.

G. Operation and Maintenance Manuals.

1. Operation and maintenance manuals shall include the following information:
 - a. Manufacturer's contact address and telephone number for parts and service.
 - b. Instruction books and/or leaflets
 - c. Recommended renewal parts list
 - d. Record Documents for the product data and submittals required above.

1.03 REFERENCE CODES AND STANDARDS

- A. All products and components shown on the Drawings and listed in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):
1. NFPA 70 – National Electrical Code (NEC)

2. NFPA 70E – Standard For Electrical Safety in the Workplace
3. NEMA Standard ICS 2 – 2000 Industrial Control and Systems
4. UL 508/508A – Industrial Control Enclosures
5. UL 1449, UL 1283 – SURGE PROTECTIVE DEVICES
6. ANSI/IEEE C62.41, C64.45 – Guide in Surge Environment in 600V Power Circuits
7. NEMA LS-1 – Low Voltage Surge Protective Devices

- B. All equipment specified in this section of the Specifications shall bear the appropriate label of Underwriters Laboratories.

1.04 QUALITY ASSURANCE

- A. The Manufacturer of these materials shall have produced similar electrical materials and equipment for a minimum period of five (5) years. When requested by the OWNER/ENGINEER, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- B. The Manufacturer of the assembly shall be the Manufacturer of the major components within the assembly. All assemblies shall be of the same Manufacturer.

1.05 DELIVERY STORAGE AND HANDLING

- A. Equipment shall be handled and stored in accordance with Manufacturer's instructions.
- B. Protect equipment and materials from exposure to the elements and keep thoroughly clean and dry until installation.
- C. Equipment submitted shall fit within the space shown on the Drawings. Equipment which does not fit within the space is not acceptable.
- D. Where space heaters are provided in equipment, provide temporary electrical power and operate space heaters during jobsite storage, and after equipment is installed in permanent location, until equipment is placed in service.

1.06 WARRANTY

- A. The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for a minimum of 2 years beginning after completion of the initial operation period. Within such period of warranty the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition. Any warranty work requiring shipping or transporting of the equipment shall be performed by the CONTRACTOR at no expense to the OWNER.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the Manufacturers listed in each product category are acceptable.

- B. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.

2.02 RATINGS

- A. The service voltage, shall be as shown on the Drawings. The overall short circuit withstand and interrupting rating of the equipment and devices shall be equal to or greater than the overall short circuit withstand and interrupting rating of the feeder device immediately upstream of the equipment.

2.03 CONSTRUCTION

A. General

1. Refer to Drawings for: actual layout and location of equipment and components; current ratings of devices, bus bars, components; protective relays, voltage ratings of devices, components and assemblies; and other required details.
2. Furnish nameplates for each device as indicated on the Drawings. Nameplates shall be laminated plastic with black letters on white background. Nameplates shall be fastened by 316 stainless steel screws. There shall be a nameplate for each controller that indicates equipment ratings, Manufacturer's name, shop order number and general information.

B. Enclosure

1. Enclosures shall be in accordance with the Area Classification and Enclosure Types as specified in Division 16 Electrical – General Provisions.

C. Internal Wiring

1. Wiring: Stranded tinned-copper, minimum size No. 14 AWG, with 600 Volt, 90 degree C, flame retardant, Type SIS, NEMA Class II, Type B wiring. Line side power wiring shall be sized for the full rating or frame size of the connected device.
2. All wiring shall be tagged and coded with an identification number. Coding shall be typed on a heat shrinkable tube applied to each end showing origination and destination of each wire. The marking shall be permanent, non-smearing, solvent-resistant type similar to Raychem TMS-SCE, or equal.
3. All control wiring to draw out units shall be run through split type terminal blocks (draw out) which can be split to allow easy unit removal. Motor "T" leads shall bolt directly to starter or overloads and shall not be split type.
4. All wiring shall be neatly bundled with ty-raps and supported to wire way supports. Control wiring shall be bundled separately from power wiring. In addition, low signal wiring (millivolt and milliamp) shall be bundle separately from the rest of the control wiring.

D. Field Installed Internal Wiring

1. Field installed interior wiring shall be neatly grouped by circuit and bound by plastic tie wraps. Circuit groups shall be supported so that circuit terminations are not stressed. In addition, low signal wiring (millivolt and milliamp) shall be bundle separately from the rest of the control wiring.

2. All field wiring shall be tagged and coded with an identification number. Coding shall be typed on a heat shrinkable tube applied to each end of the wire. The marking shall be a permanent, non-smearing, solvent-resistant type similar to Raychem TMS-SCE, or equal
3. In general, all conduit entering or leaving equipment shall be stubbed up into the bottom of the enclosure directly below the area in which the conductors are to be terminated, or from the top if shown on the Drawings. Conduits shall not enter the side unless approved in writing by the OWNER/ENGINEER.

E. Signage

1. Provide 1 inch by 3 inch engraved unit nameplates of two ply laminated plastic, black face, white core, screw fastened to each door with 316 stainless steel screws. All component and control identification nameplates shall be engraved with the device name and number exactly as it appears on the Drawings and/or as approved by the OWNER/ENGINEER. For devices not shown on the single line drawing such as time delay relays, the names shall be as shown on the Control Schematic Drawings and/or as assigned by the OWNER/ENGINEER.

F. Control Power Transformers

1. Control power transformer ratios shall be provided where shown on the Drawings. Transformer shall be sized for all the load, including space heaters, plus 25% spare capacity. Transformer mechanical ratings shall equal the short circuit rating of the circuit breaker or MCP.
2. Control power transformers shall be 120 volt grounded secondary. Primary side of the transformer shall be fused in both legs. One leg of the transformer secondary shall be solidly grounded while the other leg shall be fused.
3. All control power transformers shall have vacuum cast primary and secondary coils using epoxy resin.

G. Instrument Transformers

1. All instrument transformers shall be vacuum cast using polyurethane resin.
2. Current transformers shall be provided where shown on the Drawings. Transformer mechanical ratings shall equal the short circuit and momentary rating of the circuit breakers. Transformers, when mounted in the motor controller, shall be rated for the full voltage of the equipment.
3. Voltage transformers shall be fixed type, with primary and secondary fuses, transformer mounted, with short circuit and momentary rating equal to the motor controller.

2.04 EQUIPMENT

A. PUSHBUTTONS, INDICATING LIGHTS, AND SELECTOR SWITCHES

1. For non-hazardous, indoor, dry locations, including motor control centers, control panels, and individual stations, provide heavy-duty, 30mm oiltight type pushbuttons, push-to-test, 30mm indicating lights, selector switches, and stations for these devices. Utilize General Electric Type CR 104P, or equivalent by Cutler-Hammer, or other acceptable Manufacturer.

2. For non-hazardous, outdoor, or normally wet locations, or where otherwise indicated, provide heavy-duty corrosion-resistant, watertight type pushbuttons, push-to-test indicating lights, or selector switches mounted in NEMA 4X 316 stainless steel watertight enclosures. Provide special gasketing required to make complete station watertight. Utilize General Electric Type SK, or equivalent by Cutler-Hammer, or other Manufacturers.
3. Provide devices meeting the requirements of NEMA ICS 2, and having individual, extra-large nameplates indicating their specific function. Provide pushbutton stations with laminated plastic nameplates indicating the drive they control. Provide contacts with NEMA designation rating A600. Install provisions for locking pushbuttons and selector switches in the OFF position wherever lockout provisions are indicated.
4. Utilize selector switches having standard operating levers. Make all indicating lights push-to-test type. Provide ON or START pushbuttons colored black. Provide OFF or STOP pushbuttons colored red.

B. LIGHTNING ARRESTER AND SURGE CAPACITOR

1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - a. GE
 - b. Eaton Cutler Hammer
2. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
3. Lightning arrester shall be 650 Volt, 3 Phase, "Tranquell" type.
4. Surge Capacitor shall be 650 Volt, 3 Phase, non toxic liquid insulated.

C. WIREWAY

1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - a. GE
 - b. Eaton Cutler Hammer
 - c. Hoffman
2. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
3. NEMA 1 wireway shall be painted steel with screw covers.
4. NEMA 4 and 4X wireway shall be stainless steel with gasketed screw covers and stainless steel screws.

D. CONTROL RELAYS AND TIMERS

1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - a. GE

2. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
3. Control relays and timers: 300 volt, industrial rated, plug-in socket type, housed in a transparent polycarbonate dust cover, designed in accordance with UL Standard 508 for motor controller duty. Continuous contact rating shall be 10 amperes resistive, ¼ HP, at 120 VAC, operating temperature minus 10 to plus 55 degrees C. Provide spare N.O. & N.C. contacts. Relays shall have neon coil indicator light and 11-pin tubular. Timing relays shall be 300 volt, solid state type, multi-function, with push button selector switches to select the timing value and range, SqD JCK70 series.

E. POLYETHYLENE WARNING TAPE

1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - a. Brady Detectable Identoline
2. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
3. Warning tape shall be red polyethylene film, 2 in minimum width, with embedded metallic wire for location tracing.

F. TERMINAL BLOCKS

1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - a. GE
 - b. Eaton Cutler Hammer
2. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
3. Terminal blocks shall be 600 Volt copper, channel mounted, with tubular screw and pressure plate.
4. All terminal blocks are to be single stack. Multi-stack terminal blocks are not allowed.

G. JIC Boxes for GF Receptacles

1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - a. Hoffman, Catalog No. A 606 CHAL with Type L23 stainless steel fast operating JIC clamp.
2. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

3. JIC boxes shall be 6 in by 6 in by 4 in aluminum continuous hinge clamp cover boxes,
4. Install 1 1/2 in bushings in bottom of box for cord and plug to pass through.

H. ALARM HORN AND LIGHT

1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - a. Federal Signal Corp.; Catalog No. 350+WB for surface mounting, Catalog No. 350+FG+FB for flush mounting.
 - b. Benjamin Co.
 - c. Edwards Co.
2. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
3. Alarm horn shall be vibrating type for 120 Volts, 60 Hz.
4. Alarm light shall be a flashing strobe unit with red fresnel globe, for use on a 120 Volts, 60 Hz power supply.

I. 24 HOUR PROGRAMMABLE TIMERS

1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - a. Intermatic
 - b. Paragon
 - c. Tork
2. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
3. Unless otherwise specified, time switches shall be of the programmable type capable of being programmed at the intervals as noted on the Drawings over a 24 hour day. Program tabs shall be easily set by hand without tools to obtain or to change the desired programming schedule. The switching condition shall be maintained when adjacent tabs are set alike.
4. The unit shall be powered by a self starting, enclosed, 120 Volt, synchronous motor capable of continuous accurate operation. A reserve power, precision wound spring and associated escapement device shall be integrally mounted to maintain time settings during power failures of up to 24 hours.
5. The switch mechanism shall be a self contained unit rated at not less than 20 Amps, 120 Volts, single pole, double throw and shall be readily replaceable in the field.
6. An omitting device shall be furnished as an integral part of the time switching operation to be skipped for any preselected day or days of the week.

J. CORROSION INHIBITORS

1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

- a. Hoffman
 - b. 3M
 - 2. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
 - 3. All equipment enclosures, terminal boxes, etc, located in a NEMA 4X rated area (where shown on the Drawings) that contains electrical or electronic equipment or terminal strips shall be furnished with an internally mounted, chemically treated corrosion inhibitor pad.
- K. Equipment Identification Nameplates
- 1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - a. GE
 - b. Eaton Cutler Hammer
 - 2. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
 - 3. All field mounted electrical equipment such as disconnects, push button stations, etc, shall be provided with a weather resistant engraved laminoid equipment identification nameplate screwed or bolted adjacent to the device. Nameplate shall identify the mechanical equipment controlled exactly as shown on the electrical singleline drawings (i.e, P 95 Cooling Water Pump No. 1).
- L. EQUIPMENT MOUNTING STANDS
- 1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - a. GE
 - b. Eaton Cutler Hammer
 - c. Siemens
 - 2. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
 - 3. Equipment mounting stands shall be custom fabricated from 1/4 in aluminum plate and 4 in aluminum channel, as shown on the Drawings.
- M. LIGHTING CONTACTOR
- 1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - a. GE
 - b. Eaton Cutler Hammer
 - 2. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions.

Manufacturers listed above are not relieved from meeting these specifications in their entirety.

3. Lighting contactor shall be of the electrically operated, mechanically held type mounted in NEMA 12 enclosures (except where noted otherwise on the Drawings) with number of poles as noted on the Drawings. Operating coils shall be rated for 120 Volts unless otherwise indicated on the Drawings and shall be for momentary operation. Provide with "Hand Off-Auto" switch on cover where shown on the Drawings.
4. Contactors shall be rated for 20 Amps, 600 VAC and shall be ASCO 918 or approved equal.

N. DIGITAL LIGHTING CONTROL TIME SWITCHES

1. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - a. Tork, Catalog No. DZS 200/120 Volt DZS 200-3/277 Volt.
 - b. Tork, Catalog No. DGLC-120 Volt DGLC-3-277 Volt.
2. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
3. Time switches for lighting control shall have astronomic ON/Timed OFF and Timed ON/astronomic OFF; pulse switching for mechanically held contactors or low voltage latching relay; LCD digital display for basic setting; manual ON/OFF override and 72 hour rechargeable 9 Volt Nickel Cadmium battery back-up and NEMA III indoor/outdoor enclosure.
4. Time switches for control of lighting with photocell ON/time OFF/time ON/photocell OFF (selected days); photocell ON / photocell OFF (every day); remote photocell; 9 Volt lithium battery back-up; manual override; photocell light level control adjustment; LCD digital display and NEMA III indoor/outdoor enclosures.

PART 3 EXECUTION

3.01 INSTALLER'S QUALIFICATIONS

- A. Installer shall be specialized in installing the equipment specified in this Section with minimum 5 years documented experience. Experience documentation shall be submitted for approval prior to beginning work on this project.

3.02 EXAMINATION

- A. Examine installation area to assure there is enough clearance to install the equipment.
- B. Housekeeping pads shall be included for the floor mounted equipment as detailed on the Drawings with the exception of equipment which is to be installed adjacent to an existing unit. Housekeeping pads for these (if used) should match the existing installation.
- C. Check concrete pads and baseplates for uniformity and level surface.

- D. Verify that the equipment is ready to install.
- E. Verify field measurements are as instructed by Manufacturer.

3.03 INSTALLATION

- A. The CONTRACTOR shall install all equipment per the Manufacturer's recommendations and Contract Drawings.
- B. Installed required safety labels.

3.04 FIELD QUALITY CONTROL

- A. Inspect installed equipment for anchoring, alignment, grounding and physical damage.
- B. Check tightness of all accessible electrical connections. Minimum acceptable values are specified in Manufacturer's instructions.

3.05 FIELD ADJUSTING

- A. Adjust all circuit breakers, switches, access doors, operating handles for free mechanical and electrical operation as described in Manufacturer's instructions.
- B. The breaker protective devices shall be set in the field by a qualified representative of the Manufacturer, retained by the CONTRACTOR, in accordance with settings designated in a coordinated study of the system as required in Division 16 Power System Studies.

3.06 FIELD TESTING

- A. Perform all electrical field tests recommended by the Manufacturer. Disconnect all connections to solid-state equipment prior to testing.
- B. Megger and record phase to phase and phase to ground insulation resistance. Megger, for 1 minute, at minimum voltage of 1000 VDC. Measured Insulation resistance shall be at least 100 megohms. Measured Insulation resistance shall be at least 1 megohm. In no case shall the Manufacturer's maximum test voltages be exceeded.
- C. Test the ground fault protection system using a high current injection method.

3.07 CLEANING

- A. Remove all rubbish and debris from inside and around the equipment. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint free rags. Do not use compressed air.

3.08 EQUIPMENT PROTECTION AND RESTORATION

- A. Touch-up and restore damaged surfaces to factory finish, as approved by the Manufacturer. If the damaged surface cannot be returned to factory specification, the surface shall be replaced.

3.09 MANUFACTURER'S CERTIFICATION

- A. A qualified factory-trained Manufacturer's representative shall certify in writing that the equipment has been installed, adjusted, including all settings designated in the Power System Study, and tested in accordance with the Manufacturer's recommendations.
- B. The CONTRACTOR shall provide three (3) copies of the Manufacturer's representative's certification.

3.10 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16200

WIRES, CONDUCTORS AND CABLE – 600V AND BELOW

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Provide, furnish and install all electrical wire/s, conductor/s and cable/s (WCC) for all electrical, instrumentation and controls (EIC) work , as applicable and required, to make all electrical system/s complete and satisfactorily operable as specified herein and designated per the Drawings. Coordinate WCC accordingly for instrumentation and controls (I&C) requirements and applications.
- B. All WCC work shall comply per the National Electrical Code (NEC), all applicable federal, state, and local codes, regulations and ordinances.

1.02 SUBMITTALS

- A. Submittal/s per product information: catalog data sheets, product ratings, etc. per requirements and compliance per Division 1 – General Provisions, Section 01300, "Submittals".

1.03 RELATED WORK

- A. Drawings and all provisions of the Contract Documents shall apply to this Section, including:
 - 1. Division 16 – Electrical
 - 2. Division 17 – Process Instrumentation
 - 3. All Process and/or Mechanical Packaged System/s – having electrical, instrumentation and control system/s, WCC, components, devices, etc. Reference all applicable and respective, related packaged system/s Specification section/s, accordingly.
 - 4. Other related work as may be designated, required, and/or called for per the Drawings, other related Technical/Equipment Specifications and/or as elsewhere defined or designated.

1.04 REFERENCE STANDARDS

- A. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by basic designation only.
 - 1. ASTM: American Society for Testing and Materials
 - a. ASTM B8: – Standard Specification for concentric-lay, stranded copper conductors – hard, medium-hard, and soft.
 - 2. IECA S-95: Power Cables rated 2000V or less for distribution of electrical Energy
 - 3. NECA WC-70: Power Cables rated 2000V or less for distribution of electrical Energy
 - 4. NFPA 70: National Electric Code
 - 5. U.L. 44: Thermoset-Insulated Wires and Cables
 - 6. U.L. 510: Polyvinyl chloride, polyethylene, and rubber insulated tape

7. U.L. 1685: Vertical Tray Fire Propagation and Smoke-Release test for electrical and fiber optic cables OWNER's Conductor Color Code standard – as designated herein

1.05 OPERATION AND MAINTENANCE MANUALS

- A. Operations and Maintenance (O&M) Manuals – include all approved WCC submittals in the CONTRACT O&M per Section 01730.

PART 2 PRODUCTS

2.01 MATERIALS/CONSTRUCTION

- A. Multi-conductor I&C cable/s: Color coding is specified in the multi-conductor cable type specification – as designated per the multi-conductor cable manufacturer.
- B. Power and control WCC: provide single conductor/s with integral insulation pigmentation of the designated and/or required color. Phase colors as listed below shall be provided in all instances.
- C. Phase A, B and C implies the direction of positive phase rotation for AC power voltage.
- D. Implement OWNER's authorized conductor color code as designated below:
- Electric Power WCC compliance per COA, Austin Energy Utility

System voltage/s	Conductor	Conductor Color
a. All systems	Ground	Green
b. 120/240 volts, 1-phase, 3-wire	Hot Leg, L1 Other Hot Leg, L2 Neutral, grounded	Red Black White
c. 120/208 volts, 3-phase, 4-wire	Phase A Phase B Phase C Neutral, grounded	Red Black Blue White
d. 277/480 volts 3-phase, 3-wire *	Phase A Phase B Phase C Neutral, grounded*	Brown Yellow Purple Gray*
e. Motor space heater/s @ 120 volts, 1-phase wrapped	Hot Leg Neutral	Black Black w/white color vinyl tape
f. DC circuit installed in raceway	Positive (+) Negative (-)	Blue Brown

*3-phase, 4-wire service drop from the power company; neutral is pulled and grounded at first main disconnect only; neutral conductor shall not be installed in electrical power distribution system – thereby standard practice does not utilize 277V, 1-phase power (line to neutral)

- Control Panel WCC shall be rated 41 strand, tinned copper, 600V insulation – rated Type SIS – WCC color code as follows.

- E. All WCC shall be tagged per COA, FE AW standard per Section 16205 – Wire and Cable Tagging.

- F. Use the manufacturer's name, model or catalog number, if for purpose of establishing standard quality.
- G. Splices are not approved – exception at lighting fixture/s and convenience receptacles.
- H. Samples of all WCC shall be submitted when so requested by the OWNER/ENGINEER for the purpose of determining acceptability of the wire. WCC which have been rejected shall not be used at all. Such rejected WCC shall be removed from OWNER's premises.
- I. Multi-conductor cable is NOT APPROVED.

2.02 FUNCTIONAL REQUIREMENT

- A. Single Conductors at 600V insulation rating:
 - 1. Unless noted elsewhere or otherwise designated, all power and control WCC shall be 98% conductivity, soft annealed, stranded copper with 600V insulation – rated Type XHHW-2. Grounding WCC shall be bare, hard annealed, stranded copper.
 - 2. Use only WCC meeting applicable requirement per UL 44, UL 1685 and IECA S-95-658 (NEMA WC70).
 - 3. Power WCC shall not be smaller than #12 AWG, unless otherwise noted on the Drawings.
 - 4. Control WCC shall not be smaller than #14 AWG.
 - 5. WCC shall be marked every two feet (2'-0") with the size, type and voltage rating as well as the Manufacturer's name and measurement markers.
 - 6. Unless otherwise noted, conductor size/ampacity rating indicated are based on copper conductor. Do not provide conductor smaller than that designated – comply per N.E.C.
 - 7. Approved WCC manufacturer: Southwire.
 - 8. Where flexible power/power and controls cords and cables are supplied, provide same per Type SEOOW rated – flexible stranded copper conductor/s, 600V insulation rating – with quantity and size conductors as required and/or where designated per the Drawings.
- B. Multi Conductor Cable for VFD
 - 1. Conductors to be Class B stranded, uncoated annealed copper conforming to ASTM B-3 and B-8.
 - 2. Each conductor is insulated with black Crosslinked Polyethylene (XLP) conforming to UL Standard 44 for Type RHH/RHW-2.
 - 3. Power shall not be smaller than #8 AWG, unless otherwise noted on the Drawings.
 - 4. Each conductor is black and printed with its conductor number in accordance with IECA Method 4.
 - 5. Grounding to be Three Class B stranded, un-coated annealed copper conforming to ASTM B-3 and B-8.
 - 6. Shield is a 5 mil un-coated copper tape is helically wrapped over the twisted assembly with a 50% (nominal) overlap. The shield shall be in contact with the ground wire.
 - 7. Approved manufacturers: Southwire.

- C. Single Pair Instrumentation Cable – #16 AWG, stranded, twisted, shielded pair (2), 98% conductivity copper conductors, 600V insulation and a #16 AWG, stranded, tinned copper drain wire with overall aluminum mylar shield overlapped for 100% pair conductors coverage – rated Type TC Cable.
 - 1. Single pair instrumentation cable shall be designed and fabricated for noise rejection for process control, computer and/or data logging applications. Shall have a PVC overall jacket (35 mils) shall be flame retardant, sun light and oil resistant. Shall be rated for cable tray, conduit and/or other approved raceway. Minimum temperature rating shall be 90-degree C dry locations, 75-degree C wet locations.
- D. Single Triad Instrumentation Cable – #16 AWG, stranded, twisted, shielded triad (3) copper conductors, 600V insulation, and a #16 AWG, stranded, tinned copper drain wire with overall aluminum mylar shield overlapped for 100% triad conductors coverage – rated Type TC Cable.
 - 1. Single triad instrumentation cable shall be designed and fabricated for noise rejection for process control, computer and/or data logging applications. Shall have a PVC overall jacket (35 mils) shall be flame retardant, sun light and oil resistant. Suitable for installation in cable tray/s, conduit and/or other approved raceway/s. Minimum temperature rating shall be 90-degree C dry locations, 75-degree C wet locations.
- E. Equipment Grounding Wire/Conductor:
 - 1. Provide stranded, copper conductor/s as designated, shown and required per N.E.C. for electrical system grounding and equipment grounding.
 - 2. Provide conductor/s with green color, 600V insulation, minimum thickness of 1/32 inch – rated Type XHHW-2.
- F. All control panel wiring shall be flexible, 41 strand, tinned copper, 600V insulation, Type SIS – not smaller than #14 AWG (unless approved by Austin Water), color coded as outlined herein per Section 16200.
- G. All WCC shall be new, unused, in good condition and shall be delivered in standard coils, packages or reels. If wire used is different than what is specified, samples of wire shall be submitted for the purpose of determining acceptability of the wire. Wire which has been rejected shall not be used again. Such rejected wire shall be removed from the OWNER's premises. Decisions as to the quality of the wire furnished and the acceptance of such wire shall be made by the OWNER or OWNER's Representative.
- H. Power conductors shall not be smaller than No. 12 AWG, except for control and alarm wiring where No. 14 AWG shall be used as minimum size wire when protected by a 15 amp fuse/circuit breaker.
- I. The CONTRACTOR may, if deemed necessary or advisable, use larger sized conductors than those required. In no case shall there be a voltage drop greater than that allowed by the N.E.C.

PART 3 EXECUTION

3.01 GENERAL

- A. Do not exceed WCC manufacturer's recommendations for maximum pulling tension and minimum bending radii. Pulling compound shall be used. Use only UL listed compound compatible with WCC outer jacket and with the raceway utilized.
- B. CONTRACTOR shall provide and install all low voltage (120V, 208V, 240V, 480V, etc.) WCC for power distribution equipment and associated hardware designated and required per the Drawings.
- C. Tighten all screws and terminal bolts using torque type wrenches, and/or drives to tighten to the inch-pound requirements of the NEC and UL.
- D. When single WCC in man-holes, hand-holes, vaults, cable trays and other designated location and/or raceway(s) are not wrapped together by some other means, such as arc and fireproofing tapes, bundle throughout their exposed length conductor(s) entering from each conduit/raceway with nylon, self-locking, releasable cable ties placed at interval not exceeding 12 inches on-centers.

3.02 ERECTION, INSTALLATION AND APPLICATION INSTRUCTIONS

- A. Support all conductors in vertical conduits or raceways in the manner set forth in Article 300-19 of the latest revision of the National Electric Code. Do not use lighting fixtures for raceways or circuits other than parallel wiring of fixtures.
- B. Do not make any splices or taps in any conductor except where absolutely required for 120 volt circuits feeding lights or receptacles. Such splicing may only take place in splice/junction boxes. Elapsed time meters are the only exception to not using a junction box.
- C. Tag all power wiring in all pull boxes, wire ways, motor control center wire ways, panel board wiring gutters, light switch boxes, receptacles, disconnect switches etc. Use heat shrinkable slip-on type tags, approved for this use, as manufactured by Raychem, 3M, Panduit, or OWNER approved equal. See Section 16205, Wire and Cable Tagging Standard for additional requirements.
- D. All interconnect wiring going from one compartment to another, or between two (2) separate pieces of equipment must terminate at a terminal block on each end, i.e. entering and leaving a compartment or piece of equipment.
- E. All wiring passing between cabinets shall be protected by a rubber grommet or approved nipple with bushings.
- F. All wire terminations shall be made with a mechanical compression type lug or terminal specifically designed to accept stranded wire. Do not terminate by wrapping the wire around the screw.
- G. Number 8 AWG and larger wire shall utilize a crimper with a die set to install lugs to the wire.

- H. No more than two (2) wires/lugs per terminal will be allowed unless ring type lugs are used. A maximum of three wires will be permitted if all wires are using ring lugs.
- I. All current transformer loops shall utilize ring terminals and shorting terminal boards to avoid open circuiting the secondary of a CT.
- J. All wiring run to the front door panel shall have a spiral wrap and tie wrapped to protect wires from being pinched between door and panel. A loop (slack) in conductor(s) shall be provided to allow door to open freely.
- K. All main panel wiring shall be run in a raceway such as Panduit. All wiring run from the Panduit to the devices shall be neatly run and tie wrapped. If Panduit is not practical, wires shall be neatly run and tie wrapped.
- L. Equipment grounding wire run in conduit shall have an identifying green covering or green color coding at each end terminations and at junction box or pull box locations along its run length.
- M. Where the capacity of a single feeder is great enough to require parallel conductors in more than one (1) conduit, each conduit must contain the same number and length of conductors in all phases (legs) of the feeder, including any neutral conductors per the N.E.C.
- N. Under no circumstance shall circuits above 600 volts and those below 600 volts be pulled in the same conduit.
- O. Separate low level circuits (such as phone line) from noisy and power circuits by a minimum distance of 1 foot.
- P. Bolted and compression connections/terminations for electrical conductors shall be thoroughly cleaned, covered, and sealed with a light, pliable, waterproof film of commercial paste or sealant to prevent oxidation and/or corrosion. Apply sealant to cover complete conductor termination and cover/extend past end of conductor insulation. This is typically required for Wastewater Facilities and hazardous, damp and/or corrosive areas. Acceptable conductor/termination sealant manufacturers are Noalox or approved equal. Include sealant submittal data with WCC submittals.
- Q. Where mechanical assistance is used for pulling conductors, a wire pulling compound shall be used (Polywater, or approved equal, as indicated by conductor manufacturer) having inert qualities that do not harm the wire insulation or covering and shall be free from grease, filings or foreign matter before conductors are pulled. Do not exceed cable Manufacturer's recommendations for maximum pulling tensions and minimum bending radii.
- R. Wiring shall be tagged with Raychem Wire Markers, or approved equal, at panel boards, and all termination points with numbers conforming to Section 16205. Power wiring labels shall be white with black letters.
- S. Lighting and receptacle wiring may use silicone filled spring type wire connectors in approved locations. This applies to lighting and receptacle circuits only.

- T. In no case shall DC voltage circuits and AC circuits be pulled in the same conduit or raceway.

3.03 TESTING AND INSPECTION

- A. Field test, check and inspect all installed WCC – comply per requirements in Section 16060 – Acceptance Testing and Calibration.

3.04 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16205

WIRE AND CABLE TAGGING

PART 1 GENERAL

1.01 SUMMARY

- A. This Specification Section establishes the wire, conductor and cable tagging method to use for all electrical, control and instrumentation systems for the Austin Water.

1.02 RELATED REQUIREMENTS

- A. Work as called for on the Drawings, or in this or other Specification Sections.

PART 2 PRODUCTS

2.01 MATERIALS/CONSTRUCTION

- A. Wire, Conductor and Cable Tagging
 - 1. In general, all wiring shall be tagged at all termination points and at all major access points in the electrical raceways. A termination point is defined as any point or junction where a wire or cable is physically connected. This includes terminal blocks and device terminals. A major access point to a raceway is defined as any enclosure, box or space designed for wire pulling or inspection and includes pull boxes, manholes and junction boxes.
 - 2. Wire tags shall show both origination and destination information to allow for a wire to be traced from point-to-point in the field. Information regarding its destination shall be shown in parenthesis.
 - 3. Reference specification 16200 for wire color coding.
- B. Single Conductor, Wire and Cable Tagging
 - 1. The following is the format to use for single conductor, wire and/or cable tags. Tag information to the left refers to the origination point. Tag information in parenthesis refers to point of destination.

XXXX XX (XX-XX-XXX / XXXX XX)

Device Terminal Identifier No. (Equipment Tag No.*/Device Terminal Identifier No.)

*For wiring within a piece of equipment, control panel, junction box, etc., the Equipment Tag No. is not required, only the Device Identifier and Terminal Number from the point of origination.

Example: For a wire connected from Terminal block 1 terminal 23 to relay CR1 terminal 9, the correct tag would be TB1-23(CR1-9) at the terminal block and CR1-9(TB1-23) at the relay.

- C. Device Identifier
 - 1. The Device Identifier uniquely identifies a device within a piece of equipment. Examples are: TB1, for terminal block number 1 and CR02, for control relay # 02. For existing equipment, refer to existing device tags or labels and/or equipment documentation. For missing tags or new equipment, consult with OWNER.
- D. Terminal Number
 - 1. The Terminal Number along with the Device Identifier, identify which specific point in the equipment the wire must be terminated to. Refer to manufacturer's labeling or the Drawings for device terminal numbers.
- E. Equipment Tag No.
 - 1. The Equipment Tag Number is the physical tag attached to the equipment. For existing equipment, please refer to the Facility in question. For new or missing equipment tags please refer to the Mechanical Systems Drawings for equipment tag identification and/or designation.
- F. Tag Specifications
 - 1. Wire tags shall be yellow for control wiring and white for all AC/DC power wiring. Tags shall be heat shrink type as manufactured by Raychem, 3M, Panduit, or OWNER approved equal with the tag numbers typed with an indelible marking process. Character size shall be a minimum of 1/8" in height. Hand written tags are not allowed. Tags shall be heat shrunk once proper installation and operation is completed and verified.

PART 3 EXECUTION

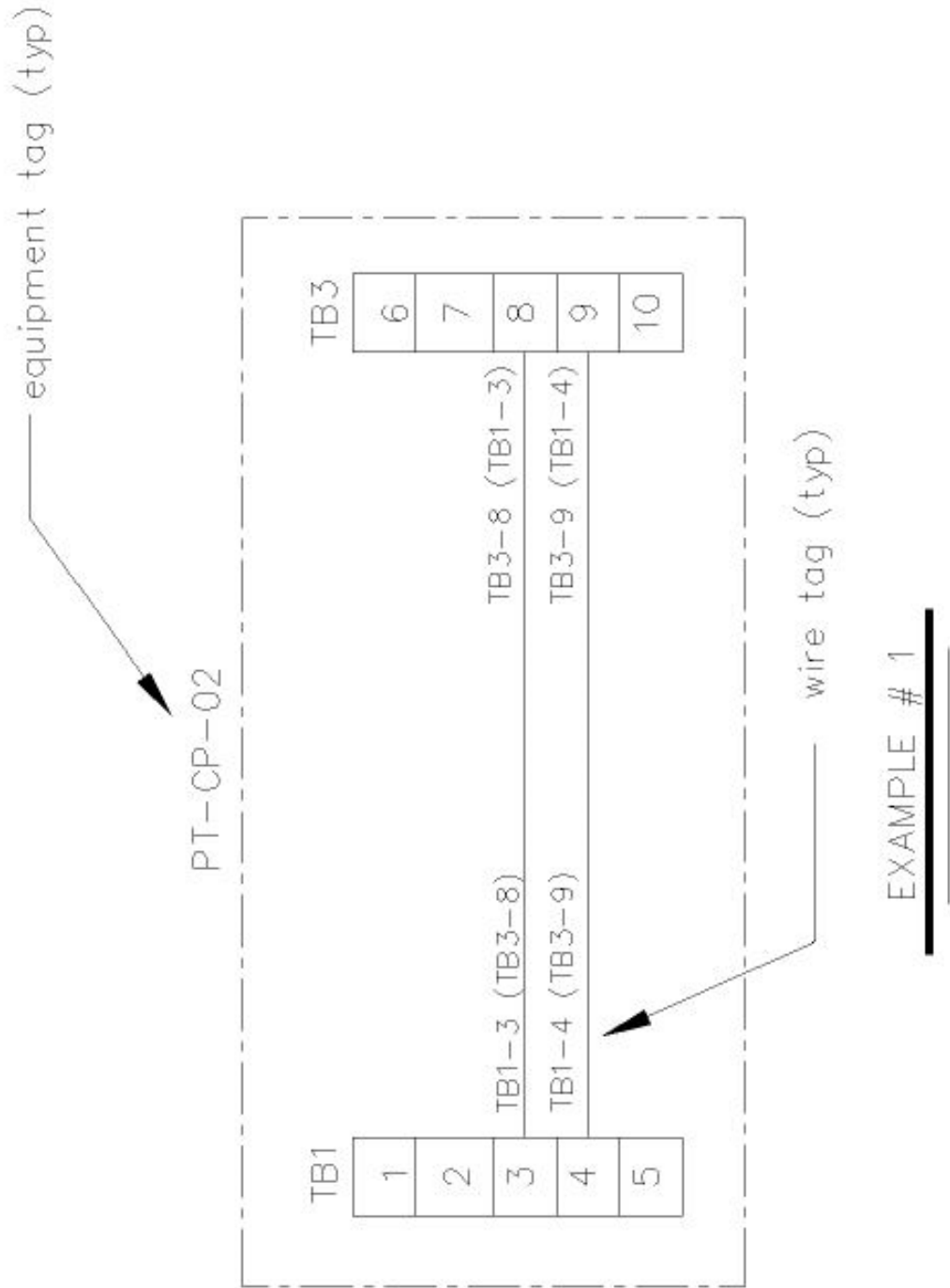
3.01 GENERAL

- A. PULL BOXES, MANHOLES, AND JUNCTION BOXES
 - 1. For all groups of conductors, tags shall be yellow Phenolic with black lettering, attached with black tie wraps. Submit tag sizing and nomenclature to OWNER for approval.
- B. DEVIATIONS
 - 1. For deviations from this wire tagging specification, or for cases not covered by these specifications, submit the proposed tagging system to Austin Water for approval prior to use.
- C. GRAPHIC DISPLAY
 - 1. Comply per the following graphic display/outline for the specified conductor/wire/cable tagging method.
 - 2. Single conductor wire tagging within same enclosure and/or equipment.
 - 3. Single conductor wire tagging between two separate enclosures and/or equipment.

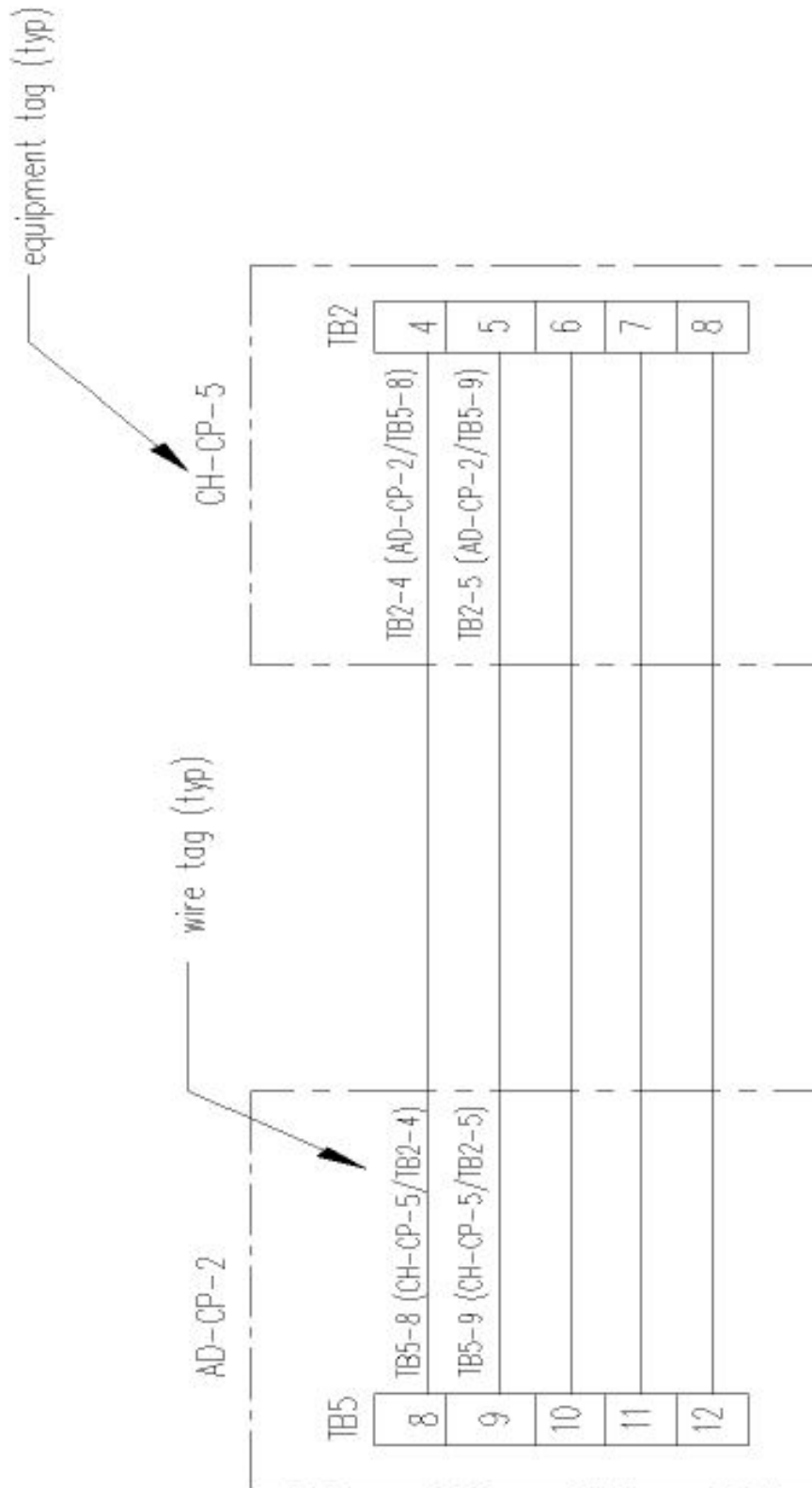
3.02 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered

subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.



Identification of a Single Conductor within a piece of equipment



END OF SECTION

EXAMPLE # 2

Identification of a Single Conductor that interconnects two pieces of equipment

SECTION 16289
SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

- A. This Section includes surge protective devices for low-voltage power, control, and communication equipment.

1.03 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. SVR: Suppressed Voltage Rating.
- C. SPD: Surge Protective Device

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated, include rated capacities, operating weights, operating characteristics, furnished specialties, and accessories.
- B. Product Certificates: For surge protective devices, signed by product Manufacturer certifying compliance with the following standards:
 - 1. UL 1283 - Electromagnetic.
 - 2. UL 1449 3rd Edition – UL Standard for Surge Protective Devices.
- C. Qualification Data: For testing agency.
- D. Field quality-control test reports, including the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Failed test results and corrective action taken to achieve requirements.
- E. Operation and Maintenance Data: For transient voltage suppression devices to include in emergency, operation, and maintenance manuals.
- F. Warranties: Special warranties specified in this Section.
- G. Submittal shall be clearly marked showing only equipment provided. Mark through equipment option not provided.
- H. Literature and drawings describing the equipment in sufficient detail, including parts list and materials of construction, to indicate full conformance with the Specifications.

- I. Submit a letter certifying full and complete compliance with the Specifications, Drawings and other project requirements. The letter shall list any exceptions or deviations from specified requirements, if any and reasons for same. Exceptions or deviation shall also be clearly marked in a separate color in submittals.

1.05 QUALITY ASSURANCE

- A. Source Limitations: Obtain surge protective devices and accessories through one source from a single Manufacturer.
- B. Product Options: Drawings indicate size, dimensional requirements, and electrical performance of suppressors and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with IEEE C62.41, "IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits," and test devices according to IEEE C62.45, "IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage (1000 Volts or less) AC Power Circuits."
- E. Comply with NEMA LS 1, "Low Voltage Surge Protection Devices."
- F. Comply with UL 1283, "Electromagnetic Interference Filters," and UL 1449, "Standard for Surge Protective Devices."

1.06 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by OWNER or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify ENGINEER not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without ENGINEER's written permission.
- B. Service Conditions: Rate surge protection devices for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
 - 2. Operating Temperature: 30 to 120 deg F (0 to 50 deg C).
 - 3. Humidity: 0 to 85 percent, non-condensing.
 - 4. Altitude: Less than 20,000 feet (6090 m) above sea level.

1.07 COORDINATION

- A. Coordinate location of field-mounted surge protective devices to allow adequate clearances for maintenance.

1.08 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which Manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within two years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, Manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. General Electric Company.
 - 2. Innovative Technology, Inc.
 - 3. Schneider Electric / Square D.
 - 4. Eaton / Cutler Hammer
 - 5. Surge Suppression Incorporated

2.02 MATERIALS / CONSTRUCTION

- A. Rate surge protection devices for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
 - 2. Operating Temperature: 30 to 120 deg F (0 to 50 deg C).
 - 3. Humidity: 0 to 85 percent, non-condensing.
 - 4. Altitude: Less than 20,000 feet (6090 m) above sea level.

2.03 480V SWITCHBOARD AND 480V MCC SUPPRESSORS

- A. Surge Protective Devices with the following features and accessories:
 - 1. Fuses, rated at 200-kA interrupting capacity.
 - 2. Fabrication using bolted compression lugs for internal wiring.
 - 3. Integral disconnect switch.
 - 4. Redundant suppression circuits.
 - 5. Redundant or replaceable modules.
 - 6. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
 - 7. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - 8. LED indicator lights for power and protection status.
 - 9. Audible alarm, with silencing switch, to indicate when protection has failed.
 - 10. One set of dry contacts, for remote monitoring of protection status. Coordinate with building power monitoring and control system.

- 11. Surge-event operations counter.
- B. Surge suppressor shall be of type 2.
- C. Peak Single-Impulse Surge Current Rating: 300kA/phase.
- D. Connection Means: Permanently wired.
- E. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 480Y/277, 3-phase, 4-wire circuits shall be as follows:
 - 1. Line to Neutral: 1200V
 - 2. Line to Ground: 1000V
 - 3. Neutral to Ground: 1000V
- F. Protection modes and UL 1449 SVR for voltages of 480, 3-phase, 3-wire, delta circuits shall be as follows:
 - 1. Line to Line: 3000V
 - 2. Line to Ground: 1500V

2.04 PANELBOARD SUPPRESSORS

- A. TVSS with the following features and accessories:
 - 1. Fuses, rated at 200-kA interrupting capacity.
 - 2. Fabrication using bolted compression lugs for internal wiring.
 - 3. Integral disconnect switch.
 - 4. Redundant suppression circuits.
 - 5. Redundant or replaceable modules.
 - 6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - 7. LED indicator lights for power and protection status.
 - 8. Audible alarm, with silencing switch, to indicate when protection has failed.
 - 9. One set of dry contacts rated at 5 A and 250Vac, for remote monitoring of protection status. Coordinate with building power monitoring and control system.
 - 10. Surge-event operations counter.
- B. Peak Single-Impulse Surge Current Rating: 120 kA/ phase
- C. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 480Y/277, 208Y/120, 3-phase, 4-wire circuits shall be as follows:
 - 1. Line to Neutral: 800 V for 480Y/277.
 - 2. Line to Ground: 800 V for 480Y/277.
 - 3. Neutral to Ground: 800 V for 480Y/277.

2.05 ENCLOSURES

- A. Install surge protective devices in the same cabinet as the MCC.

PART 3 EXECUTION

3.01 INSTALLATION OF SURGE PROTECTION DEVICES

- A. Surge protective devices shall be installed by the MCC Manufacturer at the factory.

3.02 PLACING SYSTEM INTO SERVICE

- A. Do not energize or connect service entrance equipment, panelboards, control terminals, data terminals to their sources until surge protection devices are installed and connected.

3.03 FIELD QUALITY CONTROL

- A. Remove and replace malfunctioning units and retest.

3.04 DEMONSTRATION

- A. Engage a factory-authorized service representative to train OWNER's maintenance personnel, a minimum of 2 classes, to adjust, operate, and maintain transient voltage suppression devices.

3.05 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16440

DISCONNECT SWITCHES AND ENCLOSED CIRCUIT BREAKERS

PART 1 GENERAL

1.01 WORK INCLUDED

Furnish labor, materials, equipment and incidentals necessary to install disconnects. Electrical work shall be in accordance with Division 16, GENERAL PROVISIONS.

1.02 QUALITY ASSURANCE – ACCEPTABLE MANUFACTURERS

- A. Disconnects shall comply with the specifications and shall be by the following Manufacturer:
 - 1. Square D / Schneider Electric

1.03 SUBMITTALS

- A. Submittals shall be in accordance with Division 1, SUBMITTALS and shall include:
 - 1. Disconnects

1.04 STANDARDS

- A. The applicable provisions shall apply as if written here in their entirety:
 - 1. ANSI/UL
198E NEMA RS1
Fed. Spec. FS-WS-865

PART 2 PRODUCTS

2.01 MANUFACTURED PRODUCTS

- A. DISCONNECT SWITCHES: Class "R" or non-fusible; of the required ampere rating, or as indicated on the plans; heavy duty, quick-make, quick-break, 3-phase, 3-pole switches, unless otherwise indicated.
- B. ENCLOSURES: NEMA 1, 14 gauge steel for equipment in the air conditioned rooms, and NEMA 4X, 316 stainless steel for all other locations. Furnish enclosures with interlocking covers with maintenance defeat feature and external front-operated flange-mounted switch levers. Disconnects shall have provisions for the use of three (3) safety padlocks in the "Off" position. Furnish horsepower rated switches for motor circuits. The fuse interrupting rating shall be 65,000 rms amperes.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install disconnect switches as required by the National Electrical Code. Install fuses in fusible disconnect switches.

3.02 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16441

SWITCHBOARDS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This Section includes distribution switchboard rated 600 V and less.
- B. This Section covers interconnected switchboards used as generator transfer switches.
- C. Furnish and install service entrance rated switchboard as specified herein and shown on the associated electrical drawings.

1.02 RELATED WORK

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Other sections that may relate to the work in this section include, but are not limited to, the following:
 - 1. Division 1 – General Requirements
 - 2. Division 3 – Concrete
 - 3. Division 16 – Electrical
- C. Coordinate layout and installation of switchboards and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- D. Coordinate size and location of concrete bases. Cast Type 316 stainless steel anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 – Concrete.

1.03 SCOPE OF WORK

1.04 SUBMITTALS

- A. Submit per Division 1 – General Provisions, and Section 16000 – Basic Electrical Requirements
- B. Submittal shall be clearly marked showing only equipment provided. Mark through equipment provided. Mark through equipment option not provided.
- C. Submit a letter showing all the exception to the specification. If no exceptions are taken, the letter shall indicate no exception. Submittal will be rejected without preliminary review if the letter is not submitted.
- D. Product Data: For each type of switchboard, overcurrent protective device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers'

technical data on features, performance, electrical characteristics, ratings, and finishes as well as factory test result.

- E. Shop Drawings: For each switchboard and related equipment.
 - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details
 - b. Bus configuration, current, and voltage ratings.
 - c. Short-circuit current rating of switchboards and overcurrent protective devices.
 - d. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
 - e. UL listing for series rating of installed devices.
 - f. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - g. Conduit/buses entrance locations and requirements.
 - h. One-line diagrams.
 - i. Equipment Schedule.
 - j. Switchboard instrument details.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
 - 3. SPD per Division 16.
- F. Field quality-control test reports including the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- G. Operation and Maintenance Data: For switchboards and components to include in operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
 - 1. Routine maintenance requirements for switchboards and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 3. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.05 REFERENCE STANDARDS

- A. American National Standards Institute:
 - 1. ANSI C12.1 - Code for Electricity Metering.
 - 2. ANSI C39.1 - Requirements, Electrical Analog Indicating Instruments.
 - 3. ANSI C57.13 – Instrument Transformers.
- B. Institute of Electrical and Electronics Engineers:
 - 1. IEEE C57.13 - Standard Requirements for Instrument Transformers.

2. IEEE C62.41 - Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
- C. National Electrical Contractors Association
1. NECA 400 – Standard for Installing and Maintaining Switchboards
- D. National Electrical Manufacturers Association:
1. NEMA AB 1 – Molded Case Circuit Breakers and Molded Case Switches.
 2. NEMA FU 1 - Low Voltage Cartridge Fuses.
 3. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
 4. NEMA PB 2 - Deadfront Distribution Switchboards.
 5. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less.
- E. National Fire Protection Association
1. ANSI/NFPA 70 – National Electrical Code (NEC)
 2. ANSI/NFPA70E – Electrical Safety in the Workplace
- F. International Electrical Testing Association:
1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- G. Underwriters Laboratories Inc.:
1. UL 50 – Standard for Enclosures for Electrical Equipment.
 2. UL 98 – Enclosed and Dead Front Switches.
 3. UL 489 – Molded Case Circuit Breakers.
 4. UL 943 – Ground Fault Circuit Interrupters.
 5. UL 891 – Deadfront Switchboards.
 6. UL 1053 – Ground Fault Sensing and Relaying Equipment.
 7. UL 977 – Fused Power Circuit Devices.
- 1.06 QUALITY ASSURANCE
- A. Source Limitations: Obtain switchboards through one source from a single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.

- 1.07 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)
- 1.08 DELIVERY, STORAGE, AND HANDLING
 - A. Store in accordance with Section 16000 – Basic Electrical
 - B. Specify shipping split requirements where unusual obstructions, corridor configurations, or door widths interfere with switchboard handling at site.
 - C. Accept switchboards on site. Inspect for damage.
 - D. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.
 - E. Handle in accordance with NEMA PB 2.1. and NECA 400.
- 1.09 MAINTENANCE/SPARE PARTS (NOT USED)
- 1.10 WARRANTY/EXTENDED WARRANTY
 - A. Base Warranty per Division 1.
- 1.11 SERVICES FOR MANUFACTURER'S REPRESENTATIVE
 - A. Demonstration: Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories
- 1.12 ENVIRONMENTAL REQUIREMENTS
 - A. Conform to NEMA PB 2 service conditions during and after installation of switchboards.
- 1.13 FIELD MEASUREMENTS
 - A. Verify field measurements prior to fabrication.
- 1.14 SEQUENCING
 - A. Sequence Work to avoid interferences with building finishes and installation of other products.
- 1.15 MAINTENANCE MATERIALS
 - A. Division 1 - Spare parts and maintenance products.
- 1.16 EXTRA MATERIALS
 - A. Furnish three of each size and type of fuse installed.

PART 2 PRODUCTS

2.01 DISTRIBUTION SWITCHBOARDS

- A. Manufacturers:
 - 1. Square D / Schneider Electric
- B. Product Description: NEMA PB 2, enclosed switchboard with electrical ratings and configurations as indicated on Drawings.

2.02 MATERIALS

- A. General
 - 1. Incoming Voltage: as shown on the drawings
 - 2. Bus ratings: As indicated on contract drawing.
 - 3. Short circuit current rating: as shown on the drawings
 - 4. Future Provisions: All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.
 - 5. Accessibility: Accessible from the front only. Unless rear access is provided on the room layout drawings
 - 6. Minimum Short Circuit Rating: 65,000 symmetrical amperes rms, fully rated, or as indicated in the power systems study.
 - 7. Line and Load Terminations: Accessible from front only of switchboard, suitable for conductor materials and sizes as indicated on Drawings.
 - 8. Future Provisions: Fully equip spaces for future devices with bussing and bus connections, insulated and braced for short circuit currents. Furnish continuous current rating as indicated on Drawings.
 - 9. Enclosure: NEMA 12 enclosures with gasketed door.
 - 10. Align sections at front and rear
 - 11. Finish: Manufacturer's standard light gray enamel over external surfaces. Coat internal surfaces with minimum one coat corrosion-resisting paint, or plate with cadmium or zinc.
 - 12. Enclosure: as shown on the drawings:
 - a. Sections configuration shall be as shown on contract drawing.
 - b. Switchboard heights shall be 92" including 1.5" floor sills and excluding lifting members and pull boxes.
 - c. The switchboards shall be of dead front construction.
 - d. The switchboard frame shall be of UL gauge steel and shall be of formed steel rigidly bolted together to support all cover plates, bussing and component devices during shipment and installation.
 - e. Steel base channels shall be bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting.
 - f. Each switchboard section shall have an open bottom and an individually removable top plate for installation and termination of conduit.

- g. Finish: All painted parts shall be pretreated, and provided with a corrosion-resistant, UL listed acrylic baked paint finish. The paint color shall be the standard manufacturer color. Exterior part of the enclosure shall be of galvanized steel. All exterior hardware shall be stainless steel 316.
 - h. Top and bottom conduit areas shall be clearly indicated on shop drawings.
 - i. Switchboard on non-conditioned spaces shall be provided with internal space heater to prevent condensation. The heaters shall be powered from the incoming power to the switchboard.
13. Nameplates:
- a. Main Nameplate: Provide switchboard nameplate prominently displayed on the front, indicating manufacturer's name, address and shop order number, year manufactured, and the following ratings:
 - (i) Nominal voltage rating and frequency.
 - (ii) Main bus continuous current rating.
 - (iii) Maximum 3-phase RMS (Root mean square) symmetrical short circuit current rating.
 - b. Unit Nameplates:
 - (i) Provide each unit with a black lettering on white phenolic nameplate with 3/16-inch high white lettering secured to front of unit by means of oval-head type 316 stainless steel screws, immediately below switch handle.
 - (ii) Actual nameplate legend, which may consist of up to three lines, will be provided by the Owner on shop drawings as approved.
 - (iii) Provide a preliminary list of nameplates with samples for approval by Owner.
 - c. Minic Bus Diagram – Provide a mimic bus for all switchboards with drawout type circuit breakers
 - d. Caution Signs: Provide caution signs in accordance with OSHA and NFPA 70E requirements.
14. Bus Composition: Shall be tin plated copper. Plating shall be applied continuously to all bus work. The switchboard bussing shall be of sufficient cross-sectional area to meet UL Standard 891 temperature rise requirements. The phase through-bus shall have an ampacity as shown in the plans and shall be sized to carry 100% of that ampacity. Tapered bus shall not be acceptable. Neutral bus shall terminate in the Main circuit breaker section shall be of equivalent ampacity as the phase bus bar. Full provisions for the addition of future sections shall be provided. Bussing shall include all necessary hardware to accommodate splicing for future additions. The switchboard distribution section bus shall be of the same material as the through bus and shall be rated as indicated on the drawings.
15. Bus Connections: Shall be bolted with Grade 5 bolts and conical spring washers.
16. Ground Bus: Sized per NFPA70 and UL 891 Tables 25.1 and 25.2 and shall extend the entire length of the switchboard. Provisions for the addition of the future sections shall be provided.

B. Switchboard

1. Main Breaker and Tie Breaker

- a. Electronic trip, full function 80% or 100% rated as shown on the drawings, circuit breakers
 - (i) Individually fixed mounted.
 - (a) Provide the following time/current curve shaping adjustments to maximize system selective coordination: LSIG. Each adjustment shall have discrete settings and each function is independent from all other adjustments.
 - (1) Adjustable Long Time Ampere Rating and Delay.
 - (2) Adjustable Short Time Pickup and Delay with I²t "IN" ramp.
 - (3) Adjustable Instantaneous Pickup.
 - (4) Adjustable Ground Fault Pickup and Delay.
 - (5) High Level Override
 - (b) Circuit breaker shall display phase current of A, B, and C phases and ground fault (when applicable) in real time. Circuit breaker shall contain trip indicators which shall indicate that the circuit breaker has tripped as a result of overcurrent, short circuit, or ground fault.
 - (c) Terminations
 - (1) All lugs shall be UL listed to accept solid and/or stranded copper. Lugs shall be suitable for 75° C rated wire, temperature rating tables in the NEC.
 - (2) All circuit breakers shall be UL listed to accept field installable/removable mechanical type lugs.
 - (3) All circuit breakers shall be suitable for bus connection.

C. Metering

1. Power Meter must be a standard product of the Switchboard manufacturer and installed by the Switchboard manufacturer in their production facility.
2. Accuracy: .0.2% energy accuracy
3. Communication: Ethernet/IP
4. Furnish meters with appropriate potential and current transformers as required.
5. Provide a Power Quality Meter where indicated on the drawings and for all Main Breaker.
 - a. The information displayed by the Power Meter shall include the following quantities:
 - (i) Current, per phase.
 - (ii) Volts, phase-to-phase and phase-neutral.
 - (iii) Real Power (kW), three-phase total.
 - (iv) Reactive Power (kVAR), three-phase total.
 - (v) Apparent Power (kVA), three-phase total.
 - (vi) Power Factor, true, per-phase & three-phase total.
 - (vii) Frequency.
 - (viii) Current Demand, per- phase and neutral, present and peak.
 - (ix) Real Power Demand (kWd), three- phase total, preset and peak.

- (x) Reactive Power Demand (kVARd), three- phase total, preset and peak.
- (xi) Apparent Power Demand (kVAd), three- phase total, preset and peak.
- (xii) Real Energy (kVah), three- phase total.
- (xiii) Reactive Energy (kVARh), three- phase total.
- (xiv) Apparent Energy (kVAh), three- phase total.
- (xv) Energy Accumulation Modes signed absolute, energy in, energy out.
- (xvi) Watt-hour KYZ Pulse Initiator Output.
- (xvii) Total Harmonic Distortion, Voltage.
- (xviii) Total Harmonic Distortion, Current.
- (xix) Date/Time Stamping.
- b. The Power Meter shall be accurate to .25% for voltage and current sensing, .50% for power, energy, & demand sensing, and 1% for power factor sensing.
- c. All information stored in the Power Meter shall be remotely accessible through data communications.
- d. The Power Meter shall be UL listed, rated for an operating temperature range of 0° C to 55° C and have an overcurrent withstand rating of 500 amps for 1 second.
- e. The Power Meter metering inputs shall utilize industry standard current transformers (5A secondary CT's), have VT inputs for direct connection of VT leads to up to 600V, and adhere to UL standard 508 for dielectric voltage withstand.

D. Switchboard – Distribution Section Devices

1. Feeder Circuit Breakers

- a. Electronic LSIG molded case circuit breakers, breakers shall be 80% rated.
 - (i) Group mounted.
 - (a) Circuit protective devices shall be molded case circuit breakers. Circuit breakers shall be standard, high, or extra high interruption capacity, or true current limiting as indicated in the drawings, or as result of the short circuit coordination study whichever is greater.
 - (b) Branch circuit breakers shall be group mounted bolt-on with mechanical restraint on a common pan or rail assembly.
 - (c) The interior shall have three flat bus bars aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.
 - (d) Circuit breakers equipped with line terminal jaws shall not require additional external mounting hardware. Circuit breakers shall be held in mounted position by a self-contained bracket secured to the mounting pan by fasteners. Circuit breakers of different frame size shall be capable of being mounted across from each other.
 - (e) Breaker shall be provided with Zone Selective Interlocking to provide coordinated tripping of the breaker closest to the fault.

E. Surge Protection Device (SPD)

1. Integral Surge Suppressers:

- a. Maximum single impulse current rating not less than 150 kA for each phase.
 - b. Pulse Lift Test: Capable of protecting against and surviving 5000 IEEE C62.41 Category C transients without failure or degradation.
 - c. Clamping Voltage:
 - (i) 208Y/120 Configuration:
 - (a) L-N: 500 V.
 - (b) N-G: 500 V.
 - (c) L-G: 500 V.
 - (ii) 480Y/277 Configuration:
 - (a) L-N: 1,200 V.
 - (b) N-G: 1,200 V.
 - (c) L-G: 1,200 V.
 - d. Integral Surge Suppressor Fabrication:
 - (i) Manufactured by the Panelboard Manufacturer
 - (ii) Furnish copper bus bars for surge current path.
 - (iii) Furnish with audible alarm activated when one of surge current modules has failed. Furnish alarm on/off to silence alarm and alarm push-to-test switch to test alarm. Locate switches and alarm on front cover of panel-board enclosure.
 - (iv) Furnish response time no greater than five nanoseconds for individual protection modes.
 - (v) Designed to withstand maximum continuous operating voltage (MCOV) of not less than 115 percent of nominal RMS voltage.
 - (vi) Furnish visible indication of proper suppresser connection and operation. Lights indicate operable phase and module.
 - (vii) Furnish minimum EFI/RFI filtering of 34 dB at 100 kHz with insertion loss ratio of 50:1 using Mil Std. 220A methodology.
 - e. Provide a UL label for all switchboard mounted surge suppressors
2. Shall be internal to switchboard.

2.03 FACTORY TESTS

- A. The switchboard manufacturer shall provide a minimum of two days of starting-up and testing of the switchboard.
- B. Start-up shall include inspection of the switchboard.

2.04 ACCESSORIES

- A. Furnish thermostatically controlled electric heaters in each section, sized to prevent condensation under expected weather conditions at Project site. Furnish terminals for separate connection of heater power circuit. Voltage Rating: 120 volts.

2.05 SOURCE QUALITY CONTROL

- A. Furnish shop inspection and testing in accordance with NEMA PB 2.

2.06 KIRK KEY INTERLOCK

- A. Kirk Key Interlock shall be provided as shown on the contract drawings.
 - 1. Kirk Key interlock shall be stainless steel 316.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Division 1: Coordination and project conditions.
- B. Verify surface is suitable for switchboard installation.

3.02 EXISTING WORK

- A. Disconnect and remove abandoned switchboards.
- B. Maintain access to existing switchboards and other installations remaining active.
- C. Clean and repair existing switchboards to remain or to be reinstalled.

3.03 PREPARATION

- A. Concrete Pad: Comply with requirements of Division 3.

3.04 INSTALLATION

- A. Install in accordance with NEMA PB 2.1 and NECA 400
- B. Tighten accessible bus connections and mechanical fasteners after placing switchboard.
- C. Install fuses in each switch and coordinate sizes with connected load.
- D. Install engraved plastic nameplates in accordance with Division 16.
- E. Install breaker circuit directory.
- F. Ground and bond switchboards in accordance with Division 16. All switchboard shall have a resistance to ground less than 5 ohms. Provide additional ground rods as required to achieve 5 ohms to ground

3.05 FIELD QUALITY CONTROL

- A. Division 1 - Field inspecting, testing, adjusting, and balancing.
- B. Inspect and test in accordance with NETA ATS
- C. Check tightness of accessible bolted bus joints using calibrated torque wrench per manufacturer's recommended torque values.

- D. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
- E. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
- F. Instruments, Equipment, and Reports:
 - 1. Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2. Prepare a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 ADJUSTING

- A. Adjust operating mechanisms for free mechanical movement.
- B. Tighten bolted bus connections.
- C. Adjust circuit breaker trip and time delay settings to values per the values contained in Power System Study performed by the Contractor.

3.07 CLEANING

- A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.
- B. Touch up scratched or marred surfaces to match original finish.

END OF SECTION

SECTION 16441.10

ENCLOSED SERVICE ENTRANCE CIRCUIT BREAKERS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. This Section includes enclosed service entrance circuit breakers rated 600 V and less.
- B. Furnish and install service entrance rated circuit breakers as specified herein and shown on the associated electrical drawings.

1.02 RELATED WORK

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Other sections that may relate to the work in this section include, but are not limited to, the :
 - 1. Division 1 – General
 - 2. Division 3 - Concrete
 - 3. Division 16 – Electrical.
- C. Coordinate layout and installation of enclosed circuit breaker and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- D. Coordinate size and location of concrete bases. Cast Type 316 stainless steel anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 – Concrete.

1.03 SCOPE OF WORK

1.04 SUBMITTALS

- A. Submit per Division 1 – General Provisions, and Section 16000 – Basic Electrical Requirements
- B. Submittal shall be clearly marked showing only equipment provided. Mark through equipment provided. Mark through equipment option not provided.
- C. Submit a letter showing all the exception to the specification. If no exceptions are taken, the letter shall indicate no exception. Submittal will be rejected without preliminary review if the letter is not submitted.
- D. Product Data: For each type of circuit breaker, overcurrent protective device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes as well as factory test result.

- E. Shop Drawings: For each circuit breaker and related equipment.
 - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details
 - b. Bus configuration, current, and voltage ratings.
 - c. Short-circuit current rating of switchboards and overcurrent protective devices.
 - d. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
 - e. UL listing for series rating of installed devices.
 - f. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - g. Conduit/buses entrance locations and requirements.
 - h. One-line diagrams.
 - i. Equipment Schedule.
 - j. Circuit breaker details.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
 - 3. SPD per Division 16.
- F. Field quality-control test reports including the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- G. Operation and Maintenance Data: For circuit breaker and components to include in operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:
 - 1. Routine maintenance requirements for switchboards and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 3. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.05 REFERENCE STANDARDS

- A. American National Standards Institute:
 - 1. ANSI C12.1 - Code for Electricity Metering.
 - 2. ANSI C39.1 - Requirements, Electrical Analog Indicating Instruments.
 - 3. ANSI C57.13 – Instrument Transformers.
- B. Institute of Electrical and Electronics Engineers:
 - 1. IEEE C57.13 - Standard Requirements for Instrument Transformers.
 - 2. IEEE C62.41 - Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

- C. National Electrical Contractors Association
 - 1. NECA 400 – Standard for Installing and Maintaining Switchboards
 - D. National Electrical Manufacturers Association:
 - 1. NEMA AB 1 – Molded Case Circuit Breakers and Molded Case Switches.
 - 2. NEMA FU 1 - Low Voltage Cartridge Fuses.
 - 3. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
 - 4. NEMA PB 2 - Deadfront Distribution Switchboards.
 - 5. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less.
 - E. National Fire Protection Association
 - 1. ANSI/NFPA 70 – National Electrical Code (NEC)
 - 2. ANSI/NFPA70E – Electrical Safety in the Workplace
 - F. International Electrical Testing Association:
 - 1. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
 - G. Underwriters Laboratories Inc.:
 - 1. UL 50 – Standard for Enclosures for Electrical Equipment.
 - 2. UL 98 – Enclosed and Dead Front Switches.
 - 3. UL 489 – Molded Case Circuit Breakers.
 - 4. UL 943 – Ground Fault Circuit Interrupters.
 - 5. UL 891 – Deadfront Switchboards.
 - 6. UL 1053 – Ground Fault Sensing and Relaying Equipment.
 - 7. UL 977 – Fused Power Circuit Devices.
- 1.06 QUALITY ASSURANCE
- A. Source Limitations: Obtain switchboards through one source from a single manufacturer.
 - B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
 - C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- 1.07 SYSTEM DESCRIPTION/DESIGN REQUIREMENTS (NOT USED)
- 1.08 DELIVERY, STORAGE, AND HANDLING
- A. Store in accordance with Section 16000 – Basic Electrical

- B. Specify shipping split requirements where unusual obstructions, corridor configurations, or door widths interfere with switchboard handling at site.
- C. Accept circuit breaker on site. Inspect for damage.
- D. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.
- E. Handle in accordance with NEMA PB 2.1. and NECA 400.

1.09 MAINTENANCE/SPARE PARTS (NOT USED)

1.10 WARRANTY/EXTENDED WARRANTY

- A. Base Warranty per Division 1.

1.11 SERVICES FOR MANUFACTURER'S REPRESENTATIVE

- A. Demonstration: Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories

1.12 ENVIRONMENTAL REQUIREMENTS

- A. Conform to NEMA PB 2 service conditions during and after installation of circuit breakers.

1.13 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.14 SEQUENCING

- A. Sequence Work to avoid interferences with building finishes and installation of other products.
- B. Sequence Work to minimize facility power outage.

1.15 MAINTENANCE MATERIALS

- A. Division 1 - Spare parts and maintenance products.

1.16 EXTRA MATERIALS

- A. Furnish three of each size and type of fuse installed.

PART 2 PRODUCTS

2.01 SERVICE ENTRANCE ENCLOSED CIRCUIT BREAKERS

- A. Manufacturers:
 1. Square D
 2. Substitutions: Section 01600 – Material and Equipment.

- B. Product Description: NEMA PB 2, enclosed circuit breaker, service entrance rated, in a NEMA 4X stainless steel air-conditioned enclosure, with electrical ratings and configurations as indicated on Drawings.

2.02 MATERIALS

A. General

1. Incoming Voltage: as shown on the drawings
2. Bus ratings: As indicated on contract drawing.
3. Short circuit current rating: as shown on the drawings
4. Accessibility: Accessible from left and right sides only (NO REAR ACCESS IS AVAILABLE). Unless rear access is provided on the room layout drawings
5. Minimum Short Circuit Rating: 65,000 symmetrical amperes rms, fully rated, or as indicated.
6. Line and Load Terminations: Accessible from front only of switchboard, suitable for conductor materials and sizes as indicated on Drawings.
7. Enclosure: as shown on the drawings:
 - a. NEMA 4X, Type 316 stainless steel air conditioned.
 - b. Sideaccess doors with 3 point door handle latch or removable side panels.
 - c. Dead front construction
 - d. Finish: All painted parts shall be pretreated, and provided with a corrosion-resistant, UL listed acrylic baked paint finish. The paint color shall be the standard manufacturer color. Exterior part of the enclosure shall be of 316 stainless steel. All exterior hardware shall be stainless steel 316.
 - e. Top and bottom conduit areas shall be clearly indicated on shop drawings.
 - f. Provide with internal space heater to prevent condensation. The heaters shall be powered an internal transformer in the circuit breaker enclosure.
Provide with an air-conditioning unit to prevent the breaker from overheating and to avoid derrating.
8. Nameplates:
 - a. Main Nameplate: Provide circuit breaker nameplate prominently displayed on the front, indicating manufacturer's name, address and shop order number, year manufactured, and the following ratings:
 - (i) Nominal voltage rating and frequency.
 - (ii) Main bus continuous current rating.
 - (iii) Maximum 3-phase RMS (Root mean square) symmetrical short circuit current rating.
 - b. Unit Nameplates:
 - (i) Provide each unit with a black lettering on white phenolic nameplate with 3/16-inch high white lettering secured to front of unit by means of oval-head type 316 stainless steel screws, immediately below switch handle.
 - (ii) Actual nameplate legend, which may consist of up to three lines, will be provided by the Owner on shop drawings as approved.

- (iii) Provide a preliminary list of nameplates with samples for approval by Owner.
 - c. Caution Signs: Provide caution signs in accordance with OSHA, Austin Energy, and NFPA 70E requirements.
 - 9. Bus Composition: Shall be tin plated copper. Plating shall be applied continuously to all bus work. The switchboard bussing shall be of sufficient cross-sectional area to meet UL Standard 891 temperature rise requirements. The phase through-bus shall have an ampacity as shown in the plans and shall be sized to carry 100% of that ampacity. Tapered bus shall not be acceptable. Neutral bus shall terminate in the Main circuit breaker section shall be of equivalent ampacity as the phase bus bar. Full provisions for the addition of future sections shall be provided.
 - 10. Bus Connections: Shall be bolted with Grade 5 bolts and conical spring washers.
 - 11. Ground Bus: Sized per NFPA70 and UL 891 Tables 25.1 and 25.2 and shall extend the entire length of the switchboard. Provisions for the addition of the future sections shall be provided.
- B. Main Breaker
- 1. Electronic trip, full function 80% or 100% rated as shown on the drawings, circuit breakers
 - a. Individually draw-out mounted.
 - (i) Provide the following time/current curve shaping adjustments to maximize system selective coordination: LSIG. Each adjustment shall have discrete settings and each function is independent from all other adjustments.
 - (a) Adjustable Long Time Ampere Rating and Delay.
 - (b) Adjustable Short Time Pickup and Delay with I^2t "IN" ramp.
 - (c) Adjustable Instantaneous Pickup.
 - (d) Adjustable Ground Fault Pickup and Delay.
 - (e) High Level Override
 - (ii) Circuit breaker shall display phase current of A, B, and C phases and ground fault (when applicable) in real time. Circuit breaker shall contain trip indicators which shall indicate that the circuit breaker has tripped as a result of overcurrent, short circuit, or ground fault.
 - (iii) Terminations
 - (a) All lugs shall be UL listed to accept solid and/or stranded copper. Lugs shall be suitable for 75° C rated wire, temperature rating tables in the NEC.
 - (b) All circuit breakers shall be UL listed to accept field installable/removable mechanical type lugs.
 - (c) All circuit breakers shall be suitable for bus connection.
- C. Surge Protection Device (SPD)
- 1. Integral Surge Suppressors:
 - a. Maximum single impulse current rating not less than 150 kA for each phase.
 - b. Pulse Lift Test: Capable of protecting against and surviving 5000 IEEE C62.41 Category C transients without failure or degradation.

- c. Clamping Voltage:
 - (i) 208Y/120 Configuration:
 - (a) L-N: 500 V.
 - (b) N-G: 500 V.
 - (c) L-G: 500 V.
 - (ii) 480Y/277 Configuration:
 - (a) L-N: 1,200 V.
 - (b) N-G: 1,200 V.
 - (c) L-G: 1,200 V.
 - d. Integral Surge Suppressor Fabrication:
 - (i) Manufactured by the circuit breaker manufacturer.
 - (ii) Furnish copper bus bars for surge current path.
 - (iii) Furnish with audible alarm activated when one of surge current modules has failed. Furnish alarm on/off to silence alarm and alarm push-to-test switch to test alarm. Locate switches and alarm on front cover of panel-board enclosure.
 - (iv) Furnish response time no greater than five nanoseconds for individual protection modes.
 - (v) Designed to withstand maximum continuous operating voltage (MCOV) of not less than 115 percent of nominal RMS voltage.
 - (vi) Furnish visible indication of proper suppresser connection and operation. Lights indicate operable phase and module.
 - (vii) Furnish minimum EFI/RFI filtering of 34 dB at 100 kHz with insertion loss ratio of 50:1 using Mil Std. 220A methodology.
 - e. Provide a UL label for all switchboard mounted surge suppressors
2. Shall be internal to switchboard.

2.03 FACTORY TESTS

- A. The circuit breaker manufacturer shall provide a minimum of two days of starting-up and testing of the circuit breaker.
- B. Start-up shall include inspection of the circuit breaker.

2.04 ACCESSORIES

- A. Furnish thermostatically controlled electric heaters, and air-conditioners, sized to prevent condensation and overheating under expected weather conditions at Project site. Furnish terminals for separate connection of heater and air-conditioner power circuits. Voltage Rating: 120 volts.
- B. Air conditioning system to have stainless steel enclosure.
- C. NEMA 4X Stainless Steel enclosure to be insulated to prevent condensation on exterior walls of enclosure.

- D. Enclosure to be constructed to allow Front, Left-Side, and Right-Side access only. There is NO REAR ACCESS available for this equipment. The use of removal panels on the sides will be acceptable.

2.05 SOURCE QUALITY CONTROL

- A. Furnish shop inspection and testing in accordance with NEMA PB 2.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Division 1: Coordination and project conditions.
- B. Verify surface is suitable for circuit breaker installation.

3.02 EXISTING WORK

- A. Disconnect and remove existing feeders to MCCabandoned switchboards.
- B. Maintain access to existing switchboards and other installations remaining active.
- C. Clean and repair existing switchboards to remain or to be reinstalled.

3.03 PREPARATION

- A. Concrete Pad: Comply with requirements of Division 3.

3.04 INSTALLATION

- A. Install in accordance with NEMA PB 2.1 and NECA 400
- B. Tighten accessible bus connections and mechanical fasteners after placing circuit breaker.
- C. Install engraved plastic nameplates in accordance with Division 16.
- D. Ground and bond breaker in accordance with Division 16. Resistance to ground shall be less than 5 ohms. Provide additional ground rods as required to achieve 5 ohms to ground

3.05 FIELD QUALITY CONTROL

- A. Division 1 - Field inspecting, testing, adjusting, and balancing.
- B. Inspect and test in accordance with NETA ATS
- C. Check tightness of accessible bolted bus joints using calibrated torque wrench per manufacturer's recommended torque values.
- D. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each breaker.

- E. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each breaker 11 months after date of Substantial Completion.
- F. Instruments, Equipment, and Reports:
 - 1. Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2. Prepare a certified report that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 ADJUSTING

- A. Adjust operating mechanisms for free mechanical movement.
- B. Tighten bolted bus connections.
- C. Adjust circuit breaker trip and time delay settings to values per the values contained in Power System Study performed by the Contractor.

3.07 CLEANING

- A. On completion of installation, inspect interior and exterior of breakers. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.
- B. Touch up scratched or marred surfaces to match original finish.

END OF SECTION

SECTION 16450

GROUNDING

PART 1 GENERAL

1.01 SUMMARY

- A. Provide electrical grounding system in accordance with the design Drawings, these Specifications and compliance per the NEC. Included within this section are furnishing and installing all wire/cable, ground electrodes, ground connections, ground wells/test wells, ground plates, etc. and ground testing report associated with the electrical grounding system.

1.02 RELATED REQUIREMENTS

- A. Other related work as may be designated, required, and/or called for per the Contract Drawings, other related Technical / Equipment Specifications and/ or as elsewhere defined or designated.

1.03 REFERENCES

- A. Requirements listed in the Drawings and specifications are considered additional to the standard requirements listed herein. The publications listed above form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only. Grounding system shall be designed, constructed, and tested according to the latest applicable sections of the following standards:
 - 1. ANSI American National Standards Institute
 - 2. ASTM American Society for Testing and Materials
 - 3. IEA International Energy Agency
 - 4. IEEE Institute of Electrical and Electronics Engineers
 - 5. NEC National Electrical Code
 - 6. NEMA National Electrical Manufacturers Association
 - 7. NFPA National Fire Protection Association
 - 8. UL Underwriters Laboratories
 - 9. AEIC Association of Edison Illuminating Companies
 - 10. IAE Instrumentation and Electrical
 - 11. ISA International Society of Automation
 - 12. ISO9001 International Organization for Standardization

1.04 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of Division 1 and Division 16. In addition the following specific information here in shall be complied.
- B. Submittal Data: Submit the following data for grounding system, accessories and appurtenances:

1. Manufacturer and model number(s) for all system components furnished and installed.
- C. Submit data for grounding equipment, grounding systems, materials and terminations.
- 1.05 DELIVERY STORAGE AND HANDLING
 - A. Grounding equipment, materials, supplies, etc. shall be stored off the ground and kept dry at all times, up through the time of installation. Handle with care to prevent damage, loss or compromise of its packing material.
- 1.06 OPERATION AND MAINTENANCE MANUALS
 - A. Furnish complete documentation and quantity per Division 1. As a minimum, O & M Manuals shall provide the following:
 1. All grounding testing data and report(s), per Division 16.

PART 2 PRODUCTS

2.01 MATERIALS/CONSTRUCTION

- A. Ground plate thickness shall be 0.032" with a minimum surface area of 24" x 24" (ThermOweld Part# 38-6341-"X" or approved equal). The ground plate should have Manufacturer terminated welded pigtails (sized as indicated on the Plans) or as designated per the design Drawings.
- B. Ground rods shall be 3/4" DIA x 10-ft. long copper clad steel rods and shall only be allowed for light poles, test wells and/or as required by electric utility.
- C. CONTRACTOR shall use ground enhancement material (GEM) around ground plates (ThermOweld Part# 38-6502-"XX"). GEM shall be mixed per Manufacturer's instructions to encapsulate ground plates.
- D. Ground connection and wire/cable shall be as follows:
 1. Below grade: Cadweld, Burndy Thermoweld, or approved equal thermite reaction welding system ground connection.
 2. Above grade: Burndy Type GAR, GB, GBM or GG connector as required or approved equal. Where applicable and/or as designated, install thermite weld ("Thermoweld, Cadweld, etc.") ground cable connection to all designated equipment and/or metal structural grounding above grade.
 3. Ground wire shall be green color insulation, stranded, copper conductor XHHW-2 rated for raceways/conduits and bare, stranded, annealed copper wire/conductor for underground ground grid, ground loop/s, etc. Ground wire shall be sized as designated on the designed Drawings compliance per N.E.C., not less than #6 AWG service ground and not less than #2/0 AWG bare copper ground for underground ground grid, ground loop/s, etc.
 4. Ground well/test well(s) shall be precast box with accessible cast iron lid. Lid shall read "Ground" on top. Brooks precast box, model # 3-RT, not less than 10" DIA x 12" deep or approved equal—see applicable ground well detail per the Contract

Drawings. Ground well/s located in driveway shall have AASHO H-20 traffic load rating.

PART 3 EXECUTION

3.01 ERECTION, INSTALLATION, AND APPLICATION INSTRUCTIONS

A. Ground Grid

1. Install the number of ground electrodes, ground wells/test wells as shown on the Drawings.
2. Do not cover/backfill below grade/concealed connections until each connection has been inspected by the ENGINEER/Austin Water. Where applicable and/or as designated, ditto this process for above grade ground connections to designated equipment and to metal structural ground connections.
3. Provide minimum of one ground test well accessible for ground grid testing and connection inspection. Utilize a ground test well with removable cover for accessibility from finished grade—comply as specified here-in.

B. General Equipment Grounding

1. Ground all electrical equipment, lights, receptacles, etc., with a separate equipment ground wire/conductor installed in the conduit with the power conductors. Provide/install ground wire/conductor in all conduit/raceway compliant per N.E.C.
2. Install grounding system electrically and mechanically continuous throughout. Do not bond to the system neutral except at the service transformer or service main disconnect switch or breaker.
3. Install a bonding jumper from the grounding lug on each conduit to the ground bar or bus.

C. Where the equipment has no facility to attach an equipment ground wire, use a Burndy Quicklug or equal. Clean the metal surface under the lug to bright metal so that good contact can be made. Size general equipment ground wire not less than #10 AWG, stranded copper; major equipment— panel board, motors, compressors, etc. ground wire size shall comply per N.E.C. for equipment grounding and/or per the design Drawings.

D. Provide a PVC sleeve where bare ground wire passes through concrete slab at or above ground level, where applicable.

E. Connect ground wires entering outlet boxes in such a manner that removal of the receptacle will not interrupt the continuity of the grounding circuit. A grounding screw attached to the box, and used for no other purpose, may be used to accomplish this.

F. Install a separate ground rod for lighting poles. Ground rod to be brought up through light pole foundation into base of light pole accessible via pole base hand hole. Make lighting pole ground connection to the ground rod inside the pole base (See Drawings detail).

G. Ground system "resistance" shall measure not more than 2.0 Ohms for power / instrumentation / communications / computer / network systems.

3.02 TESTING AND INSPECTION

- A. Ground system shall be calibrated and tested. Provide ground system test data and report/s – compliance per Division 16 "Acceptance Testing and Calibration".
- B. Do not cover/backfill below grade/concealed connections until each connection has been inspected by the ENGINEER. Where applicable and/or as designated, ditto this process for above grade ground connections to designated equipment and to metal structural ground connections.

3.03 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16470

PANELBOARDS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish and install panelboard(s) as specified herein and as shown on the Drawings.
- B. The provisions of this Section shall apply to all panelboards, except as indicated otherwise.

1.02 SUBMITTALS

- A. Submittals shall be made in accordance with the requirements of Division 1, Division 16 and as specified herein.
- B. Submittals shall also contain information on related equipment to be furnished under this Specification. Incomplete submittals not containing the required information on the related equipment will be returned unreviewed.
- C. Shop Drawings and Product Data. The following information shall be submitted to the ENGINEER:
 - 1. Master drawing index
 - 2. Bill of Material
 - 3. Front view elevation with dimensions
 - 4. Top view
 - 5. Nameplate schedule
 - 6. UL Listing
 - 7. Conduit entry/exit locations
 - 8. Assembly ratings including:
 - a. Short-circuit rating
 - b. Voltage
 - c. Continuous current
 - 9. Major component ratings including:
 - a. Voltage
 - b. Continuous current
 - c. Interrupting ratings
 - 10. Descriptive bulletins.
 - 11. Product data sheets.
 - 12. Cable terminal sizes
- D. Operation and Maintenance Manuals.
 - 1. Operation and maintenance manuals shall include the following information:
 - a. Manufacturer's contact address and telephone number for parts and service.
 - b. Instruction books and/or leaflets

- c. Recommended renewal parts list
- d. Record Documents for the information required by the Submittals paragraph above.
- e. Field Test Reports

1.03 REFERENCE CODES AND STANDARDS

- A. The low voltage panelboard assembly and all components in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):
 - 1. UL 67 – Panelboards
 - 2. UL 50 - Cabinets and Boxes
 - 3. NEMA PB-1 2006 - Panelboards
 - 4. NEMA AB1 Molded Case Circuit Breakers and their application
 - 5. Fed. Spec. W-P-115C
 - 6. Fed. Spec. W-C-375
- B. Operation and Maintenance Manuals.
 - 1. Equipment operation and maintenance manuals shall be provided in accordance with Division 16.
 - 2. Instruction books and/or leaflets
 - 3. Recommended renewal parts list
 - 4. Drawings and information required by the SUBMITTALS part of this Section.

1.04 QUALITY ASSURANCE

- A. Manufacturer shall be ISO 9001 2000 or later certified.
- B. The Manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the ENGINEER, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- C. Equipment submitted shall fit within the space shown on the Drawings. Equipment which does not fit within the space is not acceptable.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Protect equipment during shipment, handling, and storage by suitable complete enclosures. Protect equipment from exposure to the elements and keep thoroughly dry.
- B. Protect painted surfaces against impact, abrasion, discoloration, and other damage. Repaint damaged painted surfaces to the satisfaction of the OWNER/ENGINEER.
- C. Equipment shall not be stored onsite without written approval of the OWNER/ENGINEER. Equipment must be installed in its permanent location shown on the Drawings within seven (7) calendar days of arriving onsite. If the equipment cannot be installed within seven (7) calendar days, the equipment shall not be delivered to the

site, but stored offsite, in an air conditioned, bonded, warehouse of the CONTRACTOR's choice and at the CONTRACTOR's expense, until such time that the site is ready for permanent installation of the equipment.

- D. Shipping groups shall be designed to be shipped by truck, rail, or ship. Indoor groups shall be bolted to skids. Breakers and accessories shall be packaged and shipped separately.
- E. Where space heaters are provided in equipment, provide temporary electrical power and operate space heaters during storage, and after equipment is installed in permanent location, until equipment is placed in service.

1.06 WARRANTY

- A. The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for a minimum of 2 years beginning after completion of the initial operation period as defined in Section 01650 – Facility Start-Up / Commissioning. Within such period of warranty the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition. Any warranty work requiring shipping or transporting of the equipment shall be performed by the CONTRACTOR at no expense to the OWNER.

PART 2 PRODUCTS

2.01 PRODUCTS

- A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable.
 - 1. Square D / Schneider Electric
- B. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.02 GENERAL

- A. Rating
 - 1. Panelboard ratings shall be as shown on the Drawings. All panelboards shall be rated for the intended voltage.
 - 2. Circuit breaker panelboards shall be fully rated for the specified circuit breaker fault current interrupting capacity. Series connected short circuit ratings will not be acceptable.

2.03 MATERIALS

- A. Interiors
 - 1. All interiors shall be completely factory assembled with circuit breakers, wire connectors, etc. All wire connectors, except screw terminals, shall be of the anti turn solderless type and all shall be suitable for tinned copper wire of the sizes indicated.

2. Interiors shall be so designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuits may be changed without machining, drilling or tapping.
3. Branch circuits shall be arranged using double row construction except when narrow column panels are indicated. Branch circuits shall be numbered by the Manufacturer.
4. A nameplate shall be provided listing Manufacturer's name, panel type and rating. All nameplates shall be laminated plastic, black lettering on a white background, attached with stainless steel screws.

B. Busses.

1. All bus bars shall be tin plated copper. Full size neutral bars shall be included. Phase bussing shall be full height without reduction. Cross connectors shall be tin plated copper.
2. Neutral bussing shall have a suitable lug for each outgoing feeder requiring a neutral connection.
3. Spaces for future circuit breakers shall be bussed for the maximum device that can be fitted into them.
4. Equipment ground bars, of tin-plated copper, shall be furnished.

C. Boxes.

1. Boxes and trims shall be made from steel having multiple knockouts, unless otherwise noted. Boxes for use indoors in an air conditioned space shall be NEMA 1 steel construction, without knockouts. Boxes shall be of sufficient size to provide a minimum gutter space of 4 in on all sides.
2. At least four studs for mounting the panelboard interior shall be furnished.

D. Trim.

1. Hinged doors covering all circuit breaker handles shall be included in all panel trims.
2. Doors shall have semi flush type cylinder lock and catch, except that doors over 48 in. in height shall have a vault handle and 3 point catch, complete with lock, arranged to fasten door at top, bottom and center. Door hinges shall be concealed. Furnish two keys for each lock. All locks shall be keyed alike; directory frame and card having a transparent cover shall be furnished on each door.
3. Indoor NEMA 1 trims shall be factory painted in the Manufacturer's standard color.
4. Trims for flush panels shall overlap the box by at least 3/4 inch all around. Surface trims shall have the same width and height as the box.

2.04 CIRCUIT BREAKERS

- A. Panelboards shall be equipped with circuit breakers with frame size and trip settings as shown on the Drawings.
- B. Circuit breakers shall be fully rated molded case, bolt in type.
- C. Each circuit breaker used in 208Y/120 Volt panelboards shall have an interrupting capacity of not less than 22,000 Amps, RMS symmetrical.

- D. Each circuit breaker used in 480Y/277 Volt and 480 Volt panelboards shall have an interrupting capacity of not less than 65,000 Amps, RMS symmetrical.
- E. Circuit breakers shall be as manufactured by the panelboard Manufacturer.
- F. Single pole circuit breakers serving fluorescent lighting loads shall have the SWD marking. Circuit breakers serving air conditioning branch loads shall be U.L. listed as type HACR.

2.05 SURGE PROTECTION DEVICE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Current Technology; a subsidiary of Danahar Corporation.
 - 2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 4. Liebert Corporation.
 - 5. Siemens Energy & Automation, Inc.
- B. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, wired-in, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:
 - 1. Accessories:
 - a. Fuses rated at 200-kA interrupting capacity.
 - b. Fabrication using bolted compression lugs for internal wiring.
 - c. Integral disconnect switch.
 - d. Redundant suppression circuits.
 - e. Redundant replaceable modules.
 - f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - g. LED indicator lights for power and protection status.
 - h. Audible alarm, with silencing switch, to indicate when protection has failed.
 - i. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - j. Six-digit, transient-event counter set to totalize transient surges.
 - 2. Peak Single-Impulse Surge Current Rating: 120 kA per mode/240 kA per phase.
 - 3. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.
 - a. Line to Neutral: 70,000A.
 - b. Line to Ground: 70,000 A.
 - c. Neutral to Ground: 50,000 A.

4. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
5. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277; 208Y/120- V, three-phase, four-wire circuits shall be as follows:
 - a. Line to Neutral: 800 V for 480Y/277; 400 V for 208Y/120.
 - b. Line to Ground: 800 V for 480Y/277; 400 V for 208Y/120
 - c. Neutral to Ground: 800 V for 480Y/277; 400 V for 208Y/120.
6. Protection modes and UL 1449 SVR for 480-V, three-phase, three-wire, delta circuits shall be as follows:
 - a. Line to Line: 2000 V for 480 V; 1000 V for 240 V
 - b. Line to Ground: 1500 V for 480 V.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Mount boxes for surface mounted panelboards so there is at least 1/2 in air space between the box and the wall.
- B. Connect panelboard branch circuit loads so that the load is distributed as equally as possible between the phase busses.
- C. Type circuit directories giving location and nature of load served. Install circuit directories in each panelboard.
- D. Install the panelboard in accordance with applicable codes at each location indicated on the plans. Provide filler plates for unused spaces in the panelboard.

3.02 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing
- B. Acceptance Testing Preparation:
 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit
 2. Test continuity of each circuit.
- C. Tests and Inspections:
 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard.

Remove front panels so joints and connections are accessible to portable scanner.

- b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
- c. Instruments and Equipment:
 - (i) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.03 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16480

MOTOR CONTROL CENTER

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The CONTRACTOR shall furnish and install assemblies of low voltage motor control centers (MCC's), together with appurtenances, complete and operable, as specified herein and as shown on the Contract Drawings.
- B. Automatic transfer switches, adjustable frequency drives and programmable controllers shall be factory installed by the motor control center Manufacturer as shown on the Drawings.
- C. Motor control centers SHALL BE SIZED TO INCLUDE ALL EQUIPMENT, SPARES AND SPACES SHOWN ON THE DRAWINGS.

1.02 SUBMITTALS

- A. A pre-submittal meeting shall be held before any shop drawings are submitted. As a minimum the following shall attend the meeting: CONTRACTOR, Electrical Subcontractor, MCC Manufacturer and ENGINEER. Representatives from the MCC Manufacturer shall include the Project Manager who will be responsible for the project at the factory. Any shop drawings submitted before the pre-submittal meeting will be rejected and sent back Not Approved, Revise and Re-submit. The MCC Manufacturer shall bring with them a detailed list of the items their submittal will include for review by the ENGINEER or a bootleg copy of the actual submittal.
- B. Submittals shall be made in accordance with the requirements of Division 1, Division 16 and as specified herein.
- C. Submittals shall also contain information on related equipment to be furnished under this Specification. Incomplete submittals not containing the required information on the related equipment will be returned unreviewed.
- D. The original MCC equipment Manufacturer shall create all MCC shop drawings, including all wiring diagrams, in the Manufacturer's engineering department. All MCC shop drawings shall bear the original equipment Manufacturer's MCC logo, drawing file numbers, and shall be maintained on file in the Manufacturer's MCC archive file system. Photocopies of the Engineer's ladder schematics are unacceptable as shop drawings.
- E. Submit to the OWNER/ENGINEER, shop drawings and product data, for the following:
 - 1. Equipment outline drawings showing elevation and plan views, dimensions, weight, shipping splits and metering layouts. Indicate all options, special features, ratings and deviations from the Specifications.
 - 2. Conduit entrance drawings, including floor penetrations.
 - 3. Bus arrangement drawings.

4. Unit summary tables showing detailed equipment description and nameplate data for each compartment.
 5. Product data sheets and catalog numbers for overcurrent protective devices, motor starters, control relays, control stations, meters, pilot lights, etc. List all options, trip adjustments and accessories furnished specifically for this project.
 6. Provide control systems engineering to produce custom unit elementary drawings showing interwiring and interlocking between units and to remotely mounted devices. Show wire and terminal numbers. Indicate special identifications for electrical devices per the Drawings.
 7. Master drawing index
 8. Bill of Materials
 9. Front view elevation
 10. Floor plan
 11. Top view
 12. Single line
 13. Project Specific Schematic diagrams
 14. Nameplate schedule
 15. UL Listing
 16. Component list with detailed component information.
 17. Conduit entry/exit locations
 18. Assembly ratings including:
 - a. Short-circuit rating
 - b. Voltage
 - c. Continuous current
 19. Major component ratings including:
 - a. Voltage
 - b. Continuous current
 - c. Interrupting ratings
 20. Descriptive bulletins
 21. Product data sheets.
 22. Cable terminal sizes.
 23. Key interlock scheme drawing and sequence of operations
 24. Instruction and renewal parts books.
 25. Itemized list of spare parts furnished specifically for this project, including quantities, description and part numbers.
- F. Factory Tests. Submittals shall be made for factory tests specified herein.
- G. Field Test Reports. Submittals shall be made for field tests specified herein.
- H. Operation and Maintenance Manuals.
1. Operation and maintenance manuals shall include the following information:
 - a. Manufacturer's contact address and telephone number for parts and service.
 - b. Instruction books and/or leaflets

- c. Recommended renewal parts list
- d. Record Documents for the information required by the Submittals paragraph above.

1.03 REFERENCE CODES AND STANDARDS

- A. The low voltage motor control centers and all components in this specification shall be designed and manufactured according to latest revision of the following standards (unless otherwise noted):
 - 1. NEMA Standard ICS 2 – 2000 Industrial Control and Systems
 - 2. UL 845 – Electric Motor Control Centers
 - 3. NEMA Standard SG-3 – Low Voltage Power Circuit Breakers
 - 4. NFPA 70 – National Electrical Code (NEC)
 - 5. NFPA 70E – Standard For Electrical Safety in the Workplace
 - 6. IEEE 519-1992 – Guide for harmonic content and control
 - 7. UL508C – Power Conversion Equipment)
 - 8. UL 1449 – Surge Protective Devices;
 - 9. ANSI/IEEE C62.41, C64.45 – Guide in Surge Environment in 600V Power Circuits
 - 10. NEMA LS-1 – Low Voltage Surge Protective Devices
 - 11. NEC Art. 285 – Surge Protection Devices (SPD's)
 - 12. UL 1008 – Transfer Switches
 - 13. UL 991 – Tests for Safety-Related Controls Employing Solid-State Devices
- B. All equipment specified in this Section of the Specifications shall bear the appropriate label of Underwriters Laboratories.

1.04 QUALITY ASSURANCE

- A. The Manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of ten (10) years. When requested by the OWNER/ENGINEER, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- B. The Manufacturer of the assembly shall be the Manufacturer of the major components within the assembly. All assemblies shall be of the same Manufacturer.
- C. Equipment submitted shall fit within the space shown on the Drawings. Equipment which does not fit within the space is not acceptable.
- D. For the equipment specified herein, the Manufacturer shall be ISO 9001 2000 certified.

1.05 DELIVERY STORAGE AND HANDLING

- A. Equipment shall be handled and stored in accordance with Manufacturer's instructions.
Two
- B. (2) copies of these instructions shall be included with the equipment at time of shipment, and shall be made available to the CONTRACTOR and OWNER/ENGINEER.

- C. Shipping groups shall be designed to be shipped by truck, rail, or ship. Indoor groups shall be bolted to skids. Breakers and accessories shall be packaged and shipped separately.
- D. Equipment shall be equipped to be handled by crane. Where cranes are not available, equipment shall be suitable for skidding in place on rollers using jacks to raise and lower the groups.
- E. Equipment shall not be stored onsite without written approval of the OWNER/ENGINEER. Equipment must be installed in its permanent location shown on the Drawings within seven (7) calendar days of arriving onsite. If the equipment cannot be installed within seven (7) calendar days, the equipment shall not be delivered to the site, but stored offsite, in an air conditioned, bonded, warehouse of the CONTRACTOR's choice and at the CONTRACTOR's expense, until such time that the site is ready for permanent installation of the equipment.
- F. Where space heaters are provided in equipment, provide temporary electrical power and operate space heaters during jobsite storage, and after equipment is installed in permanent location, until equipment is placed in service.

1.06 WARRANTY

- A. The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for a minimum of 2 years beginning after completion of the initial operation period as defined in Division 1 Facility Startup / Commissioning. Within such period of warranty the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition. Any warranty work requiring shipping or transporting of the equipment shall be performed by the CONTRACTOR at no expense to the OWNER.

1.07 DESIGN CRITERIA

- A. Primary parts of the equipment, including the contactors, instrument transformers, busses, connections and insulators, shall be coordinated to withstand mechanical stress and to have sufficient thermal capacity for use on the proposed system without artificial cooling.
- B. CONTROL POWER: Control power shall be 120 VAC from a control transformer located in each combination starter. Extra control transformer VA capacity shall be furnished for powering the motor space heater in the motor which the combination starter serves. This extra VA capacity shall be in addition to the VA required for the other control components powered by the control transformer. An additional 150 VA or an additional 10% whichever is larger shall be provided above the requirement for the control components and the motor space heaters.
- C. ALLOWABLE FAULT CURRENT: Combination starters, individual components of combination starters and feeder circuit breakers in the MCC shall be rated for 65,000 Amperes interrupting capacity (AIC).
- D. Busses inside MCC shall all be braced for 65,000 Amperes of fault current.

- E. ENCLOSURE: The equipment shall be installed in NEMA 12 enclosures with gasketed door for indoor MCC's.
- F. HORSEPOWER RATING: Horsepowers as indicated on the Plans are approximate. The CONTRACTOR shall furnish properly sized motor control equipment when actual motor horsepowers are determined. If actual motor horsepowers differ from the Plans, the CONTRACTOR shall obtain assistance from the ENGINEER in determining whether or not hardware and wiring changes are necessary. The CONTRACTOR shall provide components and wire of the proper size.
- G. OPERATING VOLTAGE: The operating voltage shall be designed and arranged for operation on 480Y/277 Volt, 3 phase, 4 wire 60 Hertz.
- H. IEC or dual NEMA/IEC rated equipment shall not be acceptable.
- I. FACTORY TESTING: Equipment shall be completely assembled, wired, adjusted, and tested at the factory. After complete assembly, each unit shall be tested for operating sequence to assure accuracy of wiring, correctness of control scheme, and functioning of the equipment. Factory tests shall include electrical tests as described by ANSI C 37.20.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following Manufacturer is acceptable:
 - 1. Square D / Schneider Electric
- B. The listing of specific Manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.02 RATINGS

- A. The service voltage, overall short circuit withstand and interrupting rating of the equipment and devices shall be as shown on the Drawings. Main and feeder circuit protective devices shall be fully rated for the specified short circuit duty. Systems employing series connected ratings for main and feeder devices shall not be used. Motor starter units shall be tested and UL labeled for the specified short circuit duty in combination with the motor branch circuit protective device.
- B. The continuous current rating of the main horizontal bus shall be as shown on the Drawings. Vertical busses shall be sized for the structure load and shall have a minimum rating of 300 Amps. Bus bracing shall equal or exceed the specified equipment short circuit rating.
- C. Motor control centers, including devices, shall be designed for continuous operation at rated current in a 40 degree C ambient temperature.

- D. For additional ratings and construction notes, refer to the Drawings.

2.03 CONSTRUCTION

A. General

1. Refer to Drawings for: actual layout and location of equipment and components; current ratings of devices, bus bars, components; protective relays, voltage ratings of devices, components and assemblies; and other required details.
2. Provide engraved laminated nameplates as follows: Main equipment nameplate shall be located at the top of the MCC near the main breaker compartment. Individual compartment nameplates shall be attached to their respective doors. Provide control device nameplates for all devices screwed on near the vicinity of each device. A Manufacturer's nameplate shall be attached to the MCC giving model number, bus amps, voltage, maintenance reference documents, and other applicable information. Nameplates shall be laminated plastic with black lettering on a white nameplate. All nameplates shall be attached with stainless steel screws.
3. Controls and lights shall be heavy duty oiltight construction. Devices installed in the starter or on the door of the starter, shall be completely factory wired with connections to external devices brought to a terminal strip installed in the starter. No field wiring shall be permitted except for connections to remote devices from the terminal strip. A physical wiring diagram shall be provided on each enclosure door and shall be protected to remain intact and legible for the service life of the equipment. Control devices shall be identified as to type and Manufacturer. Pilot lights, push buttons, etc. shall be as specified.
4. Control relays, timing relays, control transformers, control circuit fuse blocks, etc., shall be grouped in the corresponding starter with control wiring kept as short as possible. Ample space shall be allowed between devices so that each component is completely accessible without removing any other device.
5. An MCC identification number nameplate shall be fastened on the vertical wireway door of each vertical structure. Each MCC bucket shall have its own identification number nameplate fastened to the bottom of the bucket so that it is visible from the front after opening the compartment door. Each control center unit shall have an engraved plastic nameplate fastened to the outside of the unit door. Engraved plastic nameplates shall have .33" high black letters on white background. Nameplates shall be fastened to the MCC with a stainless steel screw and nut on each of the nameplate. Wiring diagrams shall be provided on the inside of each compartment door and protected so that they remain attached and legible for the service life of the equipment.

B. Enclosure.

1. Indoor enclosures shall be NEMA Type 12 gasketed enclosure unless noted otherwise on the Drawings.

C. Structure.

1. Motor control centers shall consist of a series of metal enclosed, free standing, dead front vertical sections bolted together to form double wall construction between sections. Individual vertical sections shall be nominally 90 in high, 20 in wide and 20 in deep unless otherwise shown on the Drawings. Vertical sections shall be

mounted on steel channel sills. Bottom channel sills shall be mounted front and rear of the vertical sections extending the full width of each shipping split. Top of each section shall have removable plates with lifting angle. Make provisions for field installation of additional sections to each end and provide full depth cover plates (rodent barriers) at each end of the motor control center channel sills.

2. Provide continuous top and bottom horizontal wireways extending the full width of the line up, isolated from the horizontal bus. Provide a 4 in wide, full height, vertical wireway in each section, equipped with a hinged door and cable supports. Vertical wireway shall be isolated from the bus and device compartments. Wireways or other metal member's openings shall have rolled edges or protective grommets.
3. Provide individual, flange formed, pan type door with concealed hinges and quarter turn latches for each device compartment and future space. Doors shall be removable. Door removal shall not be required to withdraw starter units or feeder tap devices.
4. Motor control centers shall be designed for against the wall mounting. All wiring, bus joints and other mechanical parts requiring tightening or other maintenance shall be accessible from the front or top.
5. Each vertical section shall be divided into no more than six compartments which shall contain a feeder breaker, combination motor control unit, or other control assemblies connected to a common vertical power bus.
6. Vertical sections shall contain horizontal wire ways at top and bottom of the structure. The design shall be such to permit a continuous wiring trough from end to end of the entire width of the motor control center. End vertical sections shall have cover plates, which can be easily removed to allow continuation of wire ways and horizontal bus extensions for future addition of vertical sections.
7. The vertical section shall also have a continuous vertical raceway extending the full height of the structure and shall intersect with the horizontal raceways. This wire way shall be completely barriered from the bus compartments, the controller compartment, and the adjacent vertical units, and shall have its own separate hinged door or bolted cover.
8. Combination motor control units (Size 5 and smaller), as well as other electrical assemblies, including feeder tap units (400 amp and smaller), shall be provided with appropriately rated stab assemblies for draw out (plug-in) type construction.
9. Plug in provisions shall include a positive guide rail system and stab shrouds to insure alignment of stabs with the vertical bus. The stab shall be designed to increase bus contact pressure during a fault. The stab design shall assure a consistent low-resistance contact with the vertical bus, even after repeated insertions and removals. The unit shall be equipped with a latching mechanism to lock the drawer in an extended or stabbed position for maintenance and testing. Each draw out compartment shall have a separate hinged removable door.
10. Each unit compartment shall be provided with an individual front hinged door. Motor control and feeder units shall be interlocked mechanically with a unit disconnect device to prevent unintentional opening of the door while unit is energized. An interlock between the unit disconnect and the structure shall prevent the removal or reinsertion of the unit when the unit is in the "ON" position. Means shall be provided for releasing the interlock for intentional access and/or application of

power. Pad locking arrangements shall permit locking the disconnect device in the "OFF" position.

11. The MCC shall be furnished as a completely factory assembled unit where transportation facilities and installation requirements permit. Minimize shipping splits if required.
12. All painted steel work shall be treated with a primer coat and a finish coat, or bonderized and finished with a coat of baked enamel at the factory, such that no field painting will be required except for "touching up" of damaged areas. Color shall be Manufacturer's standard.
13. Furnish documentation with the equipment as follows: Compartments containing panel boards shall have a card holder on the inside of the door with the branch circuits clearly identified. Compartments containing motor starters shall each have an overload heater section table posted inside the door. All control compartments shall have a pocket on the inside of the door with a copy of the appropriate schematic and wiring diagram.

D. Unit Compartments.

1. Provide individual compartments for each removable combination starter and feeder tap device unit. Each vertical section shall accommodate a maximum of six compartments. Steel barriers shall isolate the top, bottom and sides of each compartment from adjacent units and wireways. Removable units shall connect to the vertical bus in each section with tin plated, self aligning, pressure type copper plug connectors. Size 6 and larger starter units may be wired directly to the bus. Removable units shall be aligned in the structure on guide rails or shelves and secured with a cam latch mechanism or racking screw.
2. Provide individual, isolated compartments for fixed mounted devices such as circuit breakers, cable lugs, metering, relaying and control devices. Main and bus tie circuit breakers shall be wired directly to the main horizontal bus. All bus connections shall be fully rated.
3. Provide the following features:
 - a. Provision to padlock removable units in a partially withdrawn TEST position, with the bus stabs disengaged.
 - b. Provision to padlock unit disconnect handles in the OFF position with up to three padlocks.
 - c. Mechanical interlock with bypass to prevent opening unit door with disconnect in the ON position, or moving disconnect to the ON position while the unit door is open.
 - d. Mechanical split type terminal blocks for disconnecting external control wiring. Terminal blocks shall be 600 volt rated, rail mounted capable of accepting #22 to #8 wires. Terminal blocks shall be Allen Bradley.
 - e. 1492 Series rated for a minimum of 25 amps or equal.
 - f. Auxiliary contact on unit disconnect to isolate control power when fed from an external source.
 - g. Disconnect operating handles and control devices.

E. Bus Systems.

1. All bussing shall be tin plated copper.

2. The bus support system shall be high dielectric strength, low moisture absorbing high impact material.
3. Bus bracing shall be 65,000 amperes RMS symmetrical unless otherwise indicated on the Contract Drawings.
4. Busses shall be of uniform cross sectional area throughout their length. Tapered bus will not be acceptable.
5. All bolted bus mating surfaces and splicing material shall be of the same plated material as the bus.
6. The main horizontal bus shall extend the entire length of the motor control center. The main bus, bars shall be rated as shown on the Contract Drawings, but shall not be less than 600 amperes.
7. Main horizontal bus: Tin plated copper, bolted joints, accessible from the front of the structure, fully rated throughout the lineup, and factory insulated by taping. All field assembled joints shall be taped after installation, equal to the factory bus taping.
8. Vertical section bus: Tin plated copper, full height, totally insulated and isolated by labyrinth design barrier of glass-reinforced polyester, or sandwich insulated/isolated busses, with shutters to cover stab openings when units are withdrawn. Provide fishtape barriers to isolate bottom wireways from lower ends of vertical bus. Bus shall be provided in each vertical draw out section.
9. Vertical busses used for a tie circuit breaker or tie feeder lugs shall be rated for a continuous capacity equivalent to the main horizontal bus rating.
10. Horizontal ground bus: Provide a 600A minimum, continuous tin plated copper ground bus that runs the entire length of the motor control center and in each section equipped with lugs for termination of feeder and branch circuit ground conductors. Connect to ground bus in adjacent sections with splice plates. Provide ground bolted connectors for 2/0 AWG minimum wire at each end of the bus.

F. Wiring.

1. Wiring: Tin plated, minimum size No. 14 AWG, with 600 Volt, 90 degree C, flame retardant, Type SIS with thermoplastic insulation, NEMA Class II, Type B. Line side power wiring shall be sized for the full rating or frame size of the connected device.
2. Identification: Numbered sleeve type wire markers at each termination point, color coding per NEMA standards and the NEC. Foreign voltage control wiring shall be yellow.
3. All control wiring to draw out units shall be run through split type terminal blocks (draw out) which can be split to allow easy unit removal. Motor "T" leads shall bolt directly to starter or overloads and shall not be split type. Terminal blocks shall be of the fully shielded, tubular screw clamp type, resilient collar design to eliminate loose connections. Terminal blocks shall be nickel or tin plated, and have exposed wire numbering corresponding to the connected wires. Terminals shall have a maximum of two wires per terminal.
4. All wiring shall be neatly bundled with cable ties or spiral wrap and supported to wire way supports. Control wiring shall be bundled separately from power wiring. In addition, low signal wiring (millivolt and milliamp) shall be bundle separately from the rest of the control wiring.

5. Where "shipping splits" are required between the control compartments and the starter cubicles, interconnecting jumper wires shall be provided for field re-connection.
6. Field installed interior wiring shall be neatly grouped by circuit and bound by plastic tie wraps. Circuit groups shall be supported so that circuit terminations are not stressed. In addition, low signal wiring (millivolt and milliamp) shall be bundle separately from the rest of the control wiring.
7. In general, all conduit entering or leaving a motor control center shall be stubbed up into the bottom horizontal wireway directly below the vertical section in which the conductors are to be terminated, or shall enter the motor control center from the top. Conduits shall not enter the motor control center from the side unless approved in writing by the OWNER/ENGINEER.
8. All field wiring shall be tagged and coded with an identification number as shown on the Drawings. Coding shall be typed on a heat shrinkable tube applied to each end showing origination and destination of each wire. The marking shall be permanent, non-smearing, solvent-resistant type similar to Raychem TMS-SCE or equivalent by Panduit.
9. Wiring in the MCC shall terminate on numbered terminal strips or power distribution blocks. No other wire connecting devices, such as wirenuts or split bolts, shall be allowed in the MCC. Each combination starter shall be provided with an individual terminal strip for control wiring. This terminal strip shall be arranged so that it is not necessary to remove control wiring from the terminal strip to remove any bucket from the MCC. This terminal strip shall be completely accessible from the front.

G. Main Section

1. The MCC main sections shall include the main and/or tie breakers, metering and power feeder entrance to the MCC. Where a power feeder entrance is shown on the Drawings, the power feeder entrance section shall be provided. Provide bus extensions and compression lugs for number and size of incoming cables as shown on the Drawings. Where main and tie breakers are shown to be key interlocked, interlocks shall be of the Kirk-Key type.
2. The Motor Control Centers shall be arranged for top or bottom entry as indicated on the Plans. Lugs sized as required for the Motor Control Center Service shall be provided in a compartment within the Incoming Line Unit. Bus shall be provided between the incoming line lugs and the main circuit breaker and between the main circuit breaker and the main horizontal bus. This bus shall have the same ampacity and same fault current bracing as the main horizontal bus. The main circuit breaker shall have the same interrupting rating as required for feeder circuit breakers in the MCC.
3. Main lugs, main circuit breakers, ground fault sensing equipment, lightning arrestors, surge capacitors, potential transformers, current transformers, switches and meters shall be installed within the incoming line unit as indicated on the Plans.

H. Main Circuit Protective Device.

1. Unless otherwise shown on the Drawings, main and tie circuit breakers, larger than a 1200 ampere rating, shall be insulated case (ICCB), 3 Pole, 600 Volt, fixed type, electrically operated with stored energy closing mechanism. Trip device shall be

solid state with adjustable long time pickup, and delay; adjustable short time pickup and delay; short time i2t switch; high range instantaneous (fixed at the breaker's short-time withstand rating), adjustable ground fault pickup and delay; ground fault delay and pickup trips for selective tripping, and overload, short circuit, and ground fault indicator lights.

2. Unless otherwise shown on the Drawings, main and tie circuit breakers 1200 ampere rating and less shall be molded case (MCCB), 3 Pole, 600 Volt, fixed type. Trip device shall be solid state with adjustable long time pickup, and delay; adjustable short time pickup and delay; short time i2t switch; adjustable ground fault pickup and delay, and ground fault delay and pickup trips for selective tripping.
3. Main and tie breakers shall be provided with GE microEntelliguard or approved equal trip units. Trip units shall be provided with advanced metering option and waveform capture option.
4. Where shown on the Drawings, breakers shall be rated for 100% continuous duty, and shall carry a UL 489 listing.
5. Main devices shall be equipped with contacts for remote status trip indication and "inhibit" function as shown on the Drawings. Device rating shall be as shown on the Drawings.

I. Feeder Protective Devices (Non-Motor Loads).

1. Unless otherwise shown on the Drawings, feeder circuit breakers shall be molded case, 3 Pole, 600 Volt, fixed type, manually operated with stored energy closing mechanism. Trip device shall be solid state with adjustable long time pickup, adjustable instantaneous, adjustable ground fault pickup and delay; ground fault delay and pickup trips for selective tripping; and overload, short circuit and ground fault indicator lights.
2. All circuit breakers, 400 amp frame and larger units shall be provided with GE microEntelliguard or approved equal trip units. Trip units shall be provided with advanced metering option and waveform capture option.

J. All Main and Feeder circuit breakers shall have provision for padlocking in the OFF position.

K. Interlocks

1. Electrical, mechanical and Kirk-Key interlocks shall be provided on breakers where shown on the Drawings.

L. Control Power Transformers

1. Furnish control power transformers where shown on the Drawings. Transformer mechanical ratings shall equal the short circuit rating of the circuit breakers. Transformers, when mounted in motor control centers, shall be rated for the full voltage of the motor control center.
2. All control power transformers shall have vacuum cast primary and secondary coils using epoxy resin.
3. CONTROL TRANSFORMER: Included in combination starter units and shall include sufficient VA capacity for powering all the devices shown in the control schematic. Each motor space heater shall be powered from the control transformer in its

combination starter. The control transformer shall be a 480 to 120 volt transformer with a fuse in each primary leg and one fuse in the secondary leg. The un-fused secondary leg shall be grounded.

4. Control power shall be 120 VAC from a control transformer located in each combination starter. Extra control transformer VA capacity shall be furnished for powering the motor space heater in the motor which the combination starter serves. This extra VA capacity shall be in addition to the VA required for the other control components powered by the control transformer. An additional 150 VA shall be provided above the requirement for the control components and the motor space heaters.

M. Instrument Transformers

1. All instrument transformers shall be vacuum cast using polyurethane resin.
2. Furnish current transformers with ratios as shown on the Drawings. Transformer mechanical ratings shall equal the short circuit and momentary rating of the circuit breakers. Transformers, when mounted in the motor control center, shall be rated for the full voltage of the switchboard.
3. Voltage transformers shall be fixed type, with primary and secondary fuses, transformer mounted, with short circuit and momentary rating equal to the motor control center. Transformer ratios shall be as shown on the Drawings.
4. INSTRUMENT CURRENT TRANSFORMERS: Capable of carrying continuously its rated primary amperes under conditions of accidental open secondary circuit without damage to the primary insulation. Burden capacity shall be adequate to supply the connected relays, meters and accessories. Three (3) instrument current transformers shall be furnished at each MCC incoming line unit.
5. INSTRUMENT POTENTIAL TRANSFORMERS: Substantial and well built, insulation meeting the requirements of the standards of ANSI. At normal ratings under usual service conditions, no part of the transformer shall exceed the heating limits specified in the standards of ANSI when serving its connected load. Where the Plans indicate an MCC to have voltage metering, two (2) instrument potential transformers shall be furnished at the MCC metering point.

N. Surge Protection Devices

1. Each motor control center shall contain a Manufacturer provided and installed, Surge Protection System, meeting the following specifications:
 - a. Maximum Surge Current - 150kA per mode, 300kA per phase.
 - b. UL Symmetrical Fault Current Withstand Rating – 200,000 Amps.
 - c. Minimum Repetitive Surge Current capacity
 - d. 1.2x50µs, 20kV, 8x20µs, 10kA Category C3 – 20,000 Impulses.
 - e. 500V, 2kA, 10x1000µs long duration – 5000 impulses.
 - f. UL SVR Rating – 1500 L-G.
 - g. MCOV – 170%
2. Connection to the motor control center shall be with a surge rated disconnect, mounted integral to the motor control center.
3. Noise attenuation shall not exceed 44db measured in accordance with the procedures outlined in accordance in NEMA LS 1 – 1992/MIL 220A.

4. Fusing shall be, a surge rated fuse, in combination with patented thermal fuse technology.
 5. Monitoring devices shall include surge counter, indicating lights, audible alarm, Form C dry contacts @ 5 amp, 125V.
 6. The SPD shall have a warranty of not less than 10 years.
- O. Provide three valve type lightning arresters and surge capacitors on each incoming line where shown on the Drawings. Arresters and capacitors shall be the product of the MCC Manufacturer and factory installed
- P. Furnish lugs for incoming line feeders, sizes as shown on the Drawings. Allow adequate clearance for bending and terminating of cable size and type specified.
- 2.04 MOTOR CONTROLLERS
- A. General
1. The Drawings indicate the approximate horsepower and intended control scheme of the motor driven equipment. Provide the NEMA size starter, circuit breaker trip ratings, control power transformers and thermal overload heater element ratings matched to the motors and control equipment actually supplied, in compliance with the NEC and the Manufacturer's heater selection tables. All variations necessary to accommodate the motors and controls as actually furnished shall be made without extra cost to the OWNER.
 2. Motor starters shall be as shown on the Drawings. All motor starters shall be combination units, full voltage non-reversing (FVNR), with adjustable instantaneous trip magnetic only circuit breakers, or motor circuit protectors (MCP), unless otherwise specified or shown on the Drawings. NEMA starter sizes and breaker trip ratings shall be as required for the horsepower indicated, but shall be in no case less than NEMA Size 1. If the Manufacturer of the equipment utilizing the motor, supplies a motor horsepower larger than that shown on the Drawings, the CONTRACTOR shall supply a motor starter sufficient in size to control the motor supplied. International (IEC) starters shall not be acceptable.
 3. Each motor starter shall have a 120 volt operating coil unless otherwise noted.
 4. NEMA Size 5 and smaller shall be draw out design with stab-on connectors engaging the vertical buses. Larger units shall be of the fixed (bolt-in) design.
 5. Overload relays shall be standard Class 20, ambient compensated, manually reset by pushbutton located on front of the compartment door. A normally closed contact shall be directly used in the start circuit and a normally open contact shall be wire to a terminal board for overload alarm.
 6. Control power transformers shall be 120 volt grounded secondary. Primary shall be fused with slow blow fuses in each phase. One leg of the transformer secondary shall be solidly grounded while the other leg shall be fused. The transformer shall be oversized for auxiliary loads as indicated on drawings, but in no case be smaller than 100 VA.
 7. Combination starters shall include a motor circuit protector (MCP) in series with a motor controller and an overload protective device. The MCP shall have an adjustable magnetic trip range in percent of rated continuous current and a trip test feature. MCP's shall be labeled in accordance with UL489.

B. Magnetic Motor Starters.

1. Motor starters shall be 2 or 3 pole, single or 3 phase as required, 60 Hertz, 600 volt, magnetically operated, full voltage non reversing except as shown on the Drawings. NEMA sizes shall be as required for the horsepower shown on the Drawings. IEC rated starters are unacceptable.
2. Each motor starter shall have a 120 volt operating coil, and control power transformer. Starters shall have motor overload protection in each phase. Auxiliary contacts shall be provided as shown on the Drawings. A minimum of one N.O. and one N.C. auxiliary contacts shall be provided in addition to the contacts shown on the Drawings.
3. The magnetic starter shall have three (3) external manual reset thermal overload relays of either the bimetallic type or the melting alloy type. Overload relays shall be either ambient compensated or ambient insensitive. Overload relay heaters shall be Class 10 for submersible pump motors and hermetically sealed motors and shall be Class 20 for all other motors. Overload relay heaters shall be selected to produce an overload trip at no more than the following percent of the motor nameplate full load current rating:

Motors with a marked service factory not

less than 1.15	125%
Motors with a marked temperature rise of not over 40°C	125%
All other motors	115%

4. Overload relays shall be adjustable, ambient compensated and manually reset. Overload relays shall be resettable from outside the enclosure by means of an insulated bar or button. Auxiliary contacts shall be furnished on the circuit breaker or MCP operating mechanism, the starter contactor and on the overload sensing unit as shown on the Plans
5. Control power transformers shall be sized for additional load of 150VA or an additional 10% whichever is larger. Transformer primary shall be equipped with slow blow fuses. Control power transformers shall not be located behind other components and shall be accessible for removal or replacement without removing any other component.
6. Built in control stations and indicating lights shall be furnished where shown on the Drawings.
7. All wires shall be terminated on terminal blocks and shall be tagged.
8. The control compartment shall have a pocket on the inside of the door with a copy of the appropriate schematic and wiring diagram.

C. Combination Magnetic Motor Starters.

1. Motor starters shall be a combination motor circuit protector and contactor, 2 or 3 pole, single or 3 phase as required, 60 Hertz, 600 volt, magnetically operated, full voltage non reversing unless otherwise shown on the Drawings. NEMA starter frame sizes shall be as shown on the Drawings. If the motor supplied by the equipment

supplier is larger than that shown on the Drawings, the CONTRACTOR shall supply a larger frame size corresponding to the motor supplied. Motor circuit protectors shall be molded case with adjustable magnetic trip only. They shall be specifically designed for use with magnetic motor starters. Motor circuit protectors shall be current limiting type, with additional current limiters if required. IEC rated starters are unacceptable.

2. Each motor starter shall have a 120 volt operating coil, and control power transformer. Starters shall have motor overload protection in each phase. Auxiliary contacts shall be provided as shown on the Drawings. A minimum of one N.O. and one N.C. auxiliary contacts shall be provided in addition to the contacts shown on the Drawings.
3. The magnetic starter shall have three (3) external manual reset thermal overload relays of either the bimetallic type or the melting alloy type. Overload relays shall be either ambient compensated or ambient insensitive. Overload relay heaters shall be Class 10 for submersible pump motors and hermetically sealed motors and shall be Class 20 for all other motors. Overload relay heaters shall be selected to produce an overload trip at no more than the following percent of the motor nameplate full load current rating:

Motors with a marked service factory not

less than 1.15	125%
Motors with a marked temperature rise of not over 40°C	125%
All other motors	115%

4. Overload relays shall be adjustable, ambient compensated and manually reset. Overload relays shall be resettable from outside the enclosure by means of an insulated bar or button. Auxiliary contacts shall be furnished on the circuit breaker or MCP operating mechanism, the starter contactor and on the overload sensing unit as shown on the Plans.
5. Control power transformers shall be sized for additional load of 150VA or an additional 10% whichever is larger. Transformer primary shall be equipped with time delay fuses.
6. Built in control stations and indicating lights shall be furnished where shown on the Drawings.
7. All wires shall be terminated on terminal blocks and shall be tagged.
8. The control compartment shall have a pocket on the inside of the door with a copy of the appropriate schematic and wiring diagram.

D. Variable Frequency Drives

1. Variable Frequency Drives shall be integral to the motor control center.
2. Variable Frequency Drives shall be of the same Manufacturer as the Motor Control Center.
3. Drive shall be rated a minimum of 25% more than the full load amps of the motor.

4. Drive shall convert the AC Mains power to an adjustable frequency as defined below:
 - a. For drives rated up to 100 hp, the drive shall use a 6-pulse rectifier with line reactors for harmonic mitigation. The rectifiers shall convert the AC power to a fixed DC voltage.
 - b. Incoming power section shall be insensitive to phase rotation of the AC line.
 5. The output power section shall change fixed DC voltage to an adjustable frequency AC voltage.
 6. Drive Ratings
 - a. Drives shall designed to operate in a range of 32 to 104 °F.
 - b. Voltage Rating shall be 480V +/- 10% Vac.
 - c. Frequency rating shall be 60 Hz +/- 2%.
 - d. Minimum drive efficiency at rated speed must be above 96%.
 - e. Output Frequency Range shall be 0 to 60 Hz.
 7. Each drive shall include manual ability to set the speed at the motor control center and to have 4-20 mA signal provided to the drive from SCADA.
 8. Each drive shall include the following inputs and output for SCADA:
 - a. Analog In – Speed Set Point
 - b. Analog Out – Speed Feedback
 - c. Digital In – Run
 - d. Digital Out – Running
 - e. Digital Out – Stopped
 - f. Digital Out – Drive Failure
- E. Control Stations.
1. Control stations shall be heavy duty type, with full size operators. Momentary contact stop buttons shall have a lockout latch that can be padlocked in the open position.
- F. Pushbuttons, Indicating Lights and Selector Switches.
1. Provide heavy-duty, 30mm, oil-tight type pushbuttons, selector switches, indicating lights and stations, push-to-test, for these devices. Indicating lights shall be of the LED type.
 2. Provide devices meeting the requirements of NEMA ICS 2, and having individual, extra large nameplates indicating their specific function. Provide pushbutton stations with laminated plastic nameplates indicating the drive they control, stainless steel screw attached. Provide contacts with NEMA designation rating A600. Install provisions for locking pushbuttons and selector switches in the OFF position wherever lockout provisions are indicated.
 3. Devices installed in enclosures other than control stations shall match or exceed the rating of the enclosure.
- G. Control Relays.
1. Industrial-type; contacts rated for 10 amps at 600 VAC: Allen-Bradley 700 PK, or approved equal; capability of having contact decks added in the field; field convertible to normally open or normally closed. Coils and contacts shall each be

replaceable without replacing any other part of the relay. Industrial control relays shall be furnished whether the relay coil is operated with 120 VAC or 24 VDC.

H. Timing Relays

1. Solid-state, having the capability to be hand set by an external dial. Terminals shall be front mounted and readily accessible. Ranges shall be as shown on the Plans. The timing relays shall have both normally open and normally closed contacts by having two (2) sets of form C contacts. Timing relays where shown on the plans shall be SqD JCK70 type time delay relay, or equal model, for operation on the control voltage of the equipment, etc. it is used in. Timing relays shall be provided with restraining strap.

I. Elapsed Time Meter.

1. Elapsed time meter shall be installed in each starter: Yokogawa Type 240, or approved. The meter shall be of a non-reset type, for totalizing of hours and shall operate on 120 VAC, 60 Hertz. Starter shall be provided with an elapsed time meter; Yokogawa Model 240, 3 1/2" New Big Look type elapsed time meter, or approval equal. Digital time meters are not acceptable.

J. Terminal Strips.

1. Terminal strips shall be installed for wire terminations and shall be Allen-Bradley 1492 H1 or Allen-Bradley 1492-CA2 or approved equal. Each terminal strip shall have hinged marking surfaces which snap on. Typewritten labels shall denote terminal strip numbers and shall match numbers shown on shop drawings, O&M manuals and wiring diagrams. Marking surfaces shall be Allen-Bradley 1492-N41 and labels shall be Allen-Bradley 1492-N43.

K. Phase Failure, Phase Reversal Relay.

1. 3-phase, phase voltage unbalance, phase reversal, phase failure and high-low voltage relay PFR furnished and installed between the MCP or circuit breaker and the motor starter contactor as shown on the Plans. The relay shall be factory wired to the necessary auxiliary relays PFR with contacts which open in the event of high voltage-low voltage phase failure, phase reversal or phase voltage unbalance. Auxiliary contacts shall be connected to control circuits as shown on the Plans. Relay shall have on and off delays with automatic reset upon return to normal operating conditions. The relay shall have two form C contacts.

2.05 METERING AND PROTECTIVE RELAYS

- A. Furnish where shown on the Drawings, a Phase Protective Relay (PPR), as shown on the Drawings, and as specified in Division 16.
- B. Furnish where shown on the Drawings, a Power Quality Meter (PM1), for each Main or Feeder Breaker, as shown on the Drawings and as specified in Division 16.

2.06 COMMUNICATION

- A. Where all remote connections for a Main Breaker Section are multiplexed into a communications network, as shown on the Drawings, the connections from the metering

and control devices shall be "daisy chained" from device to device, with the chain leaving the Section as a RS485/422 or RS232 as shown.

- B. Where a RS485 Ethernet Converter is shown, furnish an Ethernet Converter to convert the "daisy chained" communications from RS485 to Ethernet.

2.07 SPARE PARTS

- A. Provide the following spare parts:
 - 1. 3 – Control fuses of type used.
 - 2. One quart of touch-up paint.
- B. Spare parts shall be boxed or packaged for long term storage and clearly identified on the exterior of package. Identify each item with Manufacturers name, description and part number.

2.08 FACTORY TESTING

- A. The Motor Control Center shall be completely assembled, wired, and adjusted at the factory and shall be given the Manufacturer's routine shop tests and any other additional operational test to insure the workability and reliable operation of the equipment.
- B. Prior to factory testing, the Manufacturer shall check to see that all selections and settings required by the Power System Study Engineer have been performed.
- C. Factory test equipment and test methods shall conform with the latest applicable requirements of ANSI, IEEE, UL, and NEMA standards.
- D. The operational test shall include the proper connection of supply and control voltage and, as far as practical, a mockup of simulated control signals and control devices shall be fed into the boards to check for proper operation.
- E. The Manufacturer shall provide three (3) certified copies of factory test reports.

PART 3 EXECUTION

3.01 MANUFACTURER'S REPRESENTATIVE

- A. Provide the services of a qualified factory-trained Manufacturer's field engineer to assist the CONTRACTOR in installation and Start-Up of the equipment specified under this section for a period of not less than 2 working days, with not less than one working day per motor control center. The Manufacturer's field engineer shall provide technical direction and assistance to the CONTRACTOR in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.
- B. The CONTRACTOR shall provide three (3) copies of the Manufacturer's field testing report.

3.02 METERING AND PROTECTIVE RELAYS INSTALLATION

- A. The CONTRACTOR shall provide the services of a Multilin factory trained CONTRACTOR to make changes to the existing plantwide Multilin based HMI system, as specified in Division 16 Electrical – General Provisions.

3.03 INSTALLER'S QUALIFICATIONS

- A. Installer shall be specialized in installing low voltage motor control centers with minimum 5 years documented experience. Experience documentation shall be submitted for approval prior to beginning work on this project.

3.04 EXAMINATION

- A. Examine installation area to assure there is enough clearance to install the equipment.
- B. Housekeeping pads shall be included for the motor control centers as detailed on the Drawings with the exception of motor control centers which are to be installed adjacent to an existing unit. Housekeeping pads for these (if used) should match the existing installation.
- C. Check concrete pads and baseplates for uniformity and level surface.
- D. Verify that the equipment is ready to install.
- E. Verify field measurements are as instructed by Manufacturer.

3.05 INSTALLATION

- A. The CONTRACTOR shall install all equipment per the Manufacturer's recommendations and Contract Drawings.
- B. Install required safety labels.

3.06 FIELD QUALITY CONTROL

- A. Inspect installed equipment for anchoring, alignment, grounding and physical damage.
- B. Check tightness of all accessible electrical connections. Minimum acceptable values are specified in Manufacturer's instructions.

3.07 FIELD ADJUSTING

- A. Testing Agency: Engage a third party qualified testing and inspecting agency independent of the Manufacturer to perform field adjustment. Third party testing agency shall be Real Power or approved equal.
- B. Adjust all circuit breakers, switches, access doors, operating handles for free mechanical and electrical operation as described in Manufacturer's instructions.

- C. The third party testing agency shall check to confirm that all settings, designated in a coordinated study of the system as required in Section 16485 Electrical System Analysis, have been made.

3.08 FIELD TESTING

- A. Testing shall be provided as identified in section 16060. A manufacturer's representative shall review the installation of the equipment prior to third party testing.
- B. The Manufacturer's field engineer shall make all electrical field tests recommended by the Manufacturer. Disconnect all connections to solid-state equipment prior to testing.
- C. Megger and record phase to phase and phase to ground insulation resistance of each bus section. Megger, for 1 minute, at minimum voltage of 1000 VDC. Measured Insulation resistance shall be at least 100 megohms. In no case shall the Manufacturer's maximum test voltages be exceeded.
- D. Complete the following test forms:
 - 1. Motor Control Center Test Report: Before energizing the motor control center, the CONTRACTOR shall perform megohm meter tests. The measurements shall be made on all phase busing and the data checked for conformance with typical Manufacturer's data. The tests must adhere to Manufacturer's testing recommendations for the proper testing methods and test voltage levels for each piece of equipment. Readings that fall below Manufacturer's recommended values will not be acceptable and the CONTRACTOR shall be required to perform any necessary remedial action before the busing is energized. A data sheet shall be submitted to the OWNER/ENGINEER for the MCC. The test report shall include the following equipment information:
 - a. MCC (SB OR PNL) NAME AND NUMBER:
 - b. MCC (SB OR PNL) MANUFACTURER
 - c. MCC (SB OR PNL) NAMEPLATE DATA:
 - (i) VOLTS:
 - (ii) HORIZONTAL BUS AMPS:
 - (iii) MAIN BREAKER AMPS:
 - d. INSULATION TEST (MEASURED):
 - (i) PHASE A-B:
 - (ii) PHASE B-C:
 - (iii) PHASE C-A:
 - (iv) PHASE A-G:
 - (v) PHASE B-G:
 - (vi) PHASE C-G:
 - e. EQUIPMENT DISCONNECTED DURING TEST:
 - f. DATE OF TEST:
 - g. TESTED BY:

- E. Testing Agency: Engage a third party qualified testing and inspecting agency, Real Power or approved equal, to perform the following field tests and inspections and prepare test reports:
 - 1. Perform each electrical test and visual and mechanical inspection, except for optional tests, stated in NETA ATS "Motor Control Centers." Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- F. Where test reports show unsatisfactory results, the OWNER/ENGINEER may require the removal of all defective or suspected materials, equipment and/or apparatus, and their replacement with new items, all at no cost to the OWNER. The CONTRACTOR shall bear all cost for any retesting.

3.09 CLEANING

- A. Remove all rubbish and debris from inside and around the equipment. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint free rags. Do not use compressed air.

3.10 EQUIPMENT PROTECTION AND RESTORATION

- A. Touch-up and restore damaged surfaces to factory finish, as approved by the Manufacturer. If the damaged surface cannot be returned to factory specification, the surface shall be replaced.

3.11 MANUFACTURER'S CERTIFICATION

- A. The third party testing agency shall certify in writing that the equipment has been installed, adjusted, including all settings designated in the Power System Study, and tested in accordance with the Manufacturer's recommendations.
- B. The CONTRACTOR shall provide three (3) copies of the Manufacturer's certification.

3.12 TRAINING

- A. Provide Manufacturer's services for training of plant personnel in operation and maintenance of the equipment furnished under this Section.
- B. The training shall be for a period of not less than one (1) eight hour day.
- C. The cost of training program to be conducted with OWNER's personnel shall be included in the Contract Price. The training and instruction, insofar as practicable, shall be directly related to the system being supplied.
- D. Provide detailed O&M manuals to supplement the training course. The manuals shall include specific details of equipment supplied and operations specific to the project.

- E. The training session shall be conducted by a Manufacturer's qualified representative. Training program shall include instructions on the assembly, motor starters, protective devices, metering, and other major components.

3.13 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16485

ELECTRICAL SYSTEM ANALYSIS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. General: The Power System Studies: Short Circuit and Protective Device Coordination Study, Arc Flash Analysis, and Load Flow Study shall be provided by a Licensed Professional Engineer in the State of Texas for this project. Once the studies are complete, the CONTRACTOR shall be responsible for programming all devices in the field per the requirements of the studies.
- B. The electrical power system study shall be deemed to include the utility company's transformer, the OWNER's entire power distribution system, all existing and new system components. The short circuit and coordination study shall include the settings for protective relays, devices and metering for settings by the CONTRACTOR.
- C. The CONTRACTOR shall include the use of their own forces to obtain all pertinent data necessary for the successful completion of the Power System Study.

1.02 SUBMITTALS

- A. The CONTRACTOR shall provide both a hard copy of the study as well as a copy of the SKM Data Files. Submittal will include as a minimum the following information:
 - 1. One-line diagram for the equipment in the study.
 - 2. Electric Utility supply information.
 - 3. Arc Flash analysis
 - 4. Relay, device and metering settings
 - 5. Arc Flash Ratings and Protective Gear requirements for Each piece of equipment provided.
 - 6. Sample Arc Flash Label
 - 7. Preliminary submittal will be marked as Preliminary, and the Final submittal will be sealed by a Licensed Professional Engineer in the State of Texas.
- B. Final submittal will include Arc Flash Labels Applied in the field by the Company providing the Arc Flash Study.

1.03 REFERENCE CODES AND STANDARDS

- A. The study shall be in accordance with the following codes and Standards:
 - 1. IEEE Standard 1584 Guide for Performing Arc-Flash Hazard Calculations.
 - 2. NFPA 70E Standard for Electrical Safety for Employee Workplaces
 - 3. NFPA 70 National Electrical Code
- B. The Study must be completed in SKM Power Tools Engineering Analysis Software, latest Version.

1.04 QUALITY ASSURANCE

- A. The study shall be performed by an Electrical Engineering Service firm who is regularly engaged in power system studies. The study shall be performed by an independent company licensed in the state of Texas.
- B. Contractor shall use Qualification Based Selection (QBS) process consistent with Professional Service Procurement Act, Chapter 2254.04 of the Texas Government Code, when securing the services of a Professional Engineer. It is a violation of State Law to solicit bids for the services of a Professional Engineer.

PART 2 STUDIES

2.01 SHORT CIRCUIT COORDINATION STUDY

- A. Provide a complete short circuit study. Include three phase and phase-to-ground calculations. Provide an equipment interrupting or withstand evaluation based on the actual equipment and model numbers provided on this project. Generic devices are not acceptable. Normal system operating method, alternate operation, and operations that could result in maximum fault conditions, shall be thoroughly addressed in the study. The study shall assume all motors are operating at rated voltage with the exception that motors, identified as "standby," shall not be included. Electrical equipment bus impedances shall be assumed as zero. Short circuit momentary duties and interrupting duties shall be calculated on the basis of maximum available fault current at the switchgear busses, switchboard busses, motor control centers and panelboards. The study shall be performed using actual available short circuit currents available as obtained from the Electric Utility. An assumption of infinite bus for the purposes of the study is not acceptable.
- B. Provide a protective device coordination study. The study shall include all electrical equipment provided under this contract and any up-stream or downstream equipment that has an impact on the coordination study. The study shall show transformer damage curves, cable short circuit-withstand curves and motor curves. Include all medium voltage switchgear, distribution switchboards, motor control centers, and 480 Volt panelboard main circuit breakers. Complete the short circuit study down to the main breaker or largest feeder on all 480 Volt panelboards. Panel board branch circuit devices need not be considered. The phase overcurrent and ground-fault protection shall be included as well as settings for all other adjustable protective devices. All motor monitoring relays and protective or monitoring devices that are a part of a supplier's equipment, such as soft starters or adjustable frequency drives, shall be included. Include the last protective device in the Electric Utilities system feeding each facility being considered.
- C. An equipment evaluation study shall be performed to determine the adequacy of the fault bracing of all bus from the panel board level up to the main switchgear or protective device. Include circuit breakers, controllers, surge arresters, busway, switches, and fuses by tabulating and comparing the short circuit ratings of these devices with the available fault currents.

- D. Selective device coordination is required between protective devices in equipment specified in each Section of the Electrical Specifications, and between each piece of electrical equipment, including existing equipment, supplied for this project. If in the course of the work, the Study Engineer determines that selective coordination cannot be obtained in or between pieces of existing and new equipment as specified, shall notify and provide supporting information to the CONTRACTOR immediately, who shall then transmit the information to the OWNER/ENGINEER for resolution of the problem. The study shall be signed and sealed by a licensed Professional Engineer in the State of Texas. As a minimum, each short circuit study shall include the following:
1. One-Line Diagram:
 - a. Location and function of each protective device in the system, such as relays, direct-acting trips, fuses, etc.
 - b. Type designation, current rating, range or adjustment, Manufacturer's style and catalog number for all protective devices.
 - c. Power and voltage ratings, impedance, primary and secondary connections of all transformers. Use the ratings of the actual transformers being provided where available.
 - d. Type, Manufacturer, and ratio of all instrument transformers energizing each relay.
 - e. Nameplate ratings of all motors and generators with their sub transient reactance.
 - f. Sources of short circuit currents such as utility ties, generators, synchronous motors, and induction motors. Provide short circuit studies using each source of power separately. The study shall determine if there is sufficient short circuit current to adequately cause interruption of a protective device using the weaker power source (typically local generation), and shall determine if the equipment can safely interrupt the fault if the greater power source is connected. Additional short circuit calculations shall include emergency as well as normal switching conditions as well as normal and emergency power sources described here in.
 - g. All significant circuit elements such as transformers, cables, breakers, fuses, reactors, etc shall be included.
 - h. The time-current setting of existing adjustable relays and direct-acting trips, if applicable.
 2. Impedance Diagram:
 - a. Available MVA or impedance from the utility company.
 - b. Local generated capacity impedance.
 - c. Transformer and/or reactor impedances.
 - d. Cable impedances.
 - e. System voltages.
 - f. Grounding scheme (resistance grounding, solid grounding, or no grounding).
 3. Calculations:
 - a. Determine the paths and situations where short circuit currents are the greatest. Assume bolted faults and calculate the 3-phase and line-to-ground short circuits of each case.

- b. Calculate the maximum and minimum fault currents.
- E. Provide Time-Current Curves on 8-1/2 X 11 log-log paper. Do not put more than one branch of protective devices on any one coordination curve. Include a one-line diagram and the names of each protective device in the branch on the coordination curve drawing. Provide separate drawings for ground fault coordination curves. Use the names designated in the Contract Documents. Include motor and transformer damage curves, and cable short circuit withstand curves.

2.02 ARC FLASH STUDY

- A. The Power System Study shall include an Arc Flash Hazard Study that shall present the level of arc flash hazard for each item of electrical equipment, and the appropriate level of protection required per OSHA standards.
- B. The analysis shall be performed with the aid of computer software intended for the purpose, in order to calculate Arc-Flash Incident Energy (AFIE) levels and flash protection boundary distances.
- C. The analysis shall be performed under worst-case Arc-Flash conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.
- D. The calculations shall be performed in accordance with IEEE 1584-2004 and safe approach requirements determined in accordance with NFPA-70E-2004.
- E. Results of the Analysis shall be submitted in tabular form, and shall include, device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, personal-protective equipment and AFIE levels.
- F. The study shall be signed and sealed by a licensed Professional Engineer in the State of Texas.
- G. After approval of the Study, The Study Engineer shall provide and affix labels as may be required for each item of electrical equipment furnished on the project. A typical warning sign shall be submitted with the Study for approval, and as shown below.
 - 1. Flash Hazard Protection Boundary.
 - 2. Limited Approach Boundary.
 - 3. Restricted Boundary.
 - 4. Prohibited Boundary.
 - 5. Incident Energy Level.
 - 6. Required Personal Protective Equipment Class.
 - 7. Type of Fire Rated Clothing.
- H. Size of each label shall be not less than 8 inches wide and 6 inches tall.



PART 3 EXECUTION

3.01 FIELD SERVICES

- A. Sign installation and verification
 - 1. When sign installation is completed, the CONTRACTOR and the OWNER/ENGINEER shall jointly inspect the locations.
- B. Training
 - 1. The CONTRACTOR shall provide the services of a qualified instructor for a period of not less than one four-hour day to conduct a training program for the OWNER's personnel in the care, application and use of protective personal equipment described by the warning signs and installed on the project. The training shall be conducted onsite as identified by the OWNER, and shall include specific equipment locations as may be required for instruction. Applicable information from the Study shall be provided to all attendees.
 - 2. Training to be provided for a minimum of 12 attendees.
- C. The cost of the Field Services and study shall be included in the Contract Prices.
- D. The OWNER reserves the right to videotape the training for the OWNER's Use.

3.02 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 16700

COMMON CONTROL PANEL REQUIREMENTS FOR EQUIPMENT

PART 1 GENERAL

1.01 WORK INCLUDED

- A. Furnish and install a functional control panel to operate the control system as specified in the detailed mechanical equipment requirements of this Section.
- B. Obtain all required control descriptions and data from the detailed mechanical equipment requirements to this Section, the System Description and the control schematic diagrams on the Electrical Contract Drawings.
- C. Provide control system engineering to produce custom elementary drawings showing interior wiring and interlocking with remote devices.
- D. All control devices, unless specified otherwise, shall be mounted in the control panel.
- E. This section includes control panels supported by equipment Manufacturers to manually or automatically operate the mechanical equipment.

1.02 REFERENCE STANDARDS

- A. Institute of Electrical and Electronics Engineers (IEEE)
- B. National Electrical Manufacturers Association (NEMA)
- C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.03 SUBMITTALS

- A. Submit to the ENGINEER, in accordance with Division 1, shop drawings and product data for the following:
 - 1. Equipment outline drawings showing elevation, plan and interior views, front panel arrangement, dimensions, weight, shipping splits, conduit entrances and anchor bolt pattern. Indicate all options, special features, ratings and deviations from this Section. Furnish complete Bill of Materials indicating Manufacturer's part numbers.
 - 2. Power and control schematics including external connections. Show wire and terminal numbers and color coding.
 - 3. Instruction and replacement parts books.
 - 4. Certified shop test reports.
 - 5. As-built final drawings.
 - 6. Field tests and inspection reports.
- B. Literature and drawings describing the equipment in sufficient detail, including parts list and materials of construction, to indicate full conformance with the Specifications.

1.04 QUALITY ASSURANCE

- A. A factory authorized service and parts organization shall be able to respond to any service call for the project within 8 hours. Provide the name and address of the factory authorized service and parts organization nearest to the project location at the time of the bid.
- B. Equipment components and devices shall be UL labeled to the extent possible wherever UL standards exist for such equipment.
- C. The control panel Manufacturer shall demonstrate at least three years of continuous field operating experience in control panel design and fabrication. Submit customer/user list with telephone numbers, addresses and names of customer/user representatives.

1.05 SYSTEM DESCRIPTION

- A. Refer to the detailed mechanical equipment specifications for description of system operation.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Package the control panel for maximum protection during delivery and storage.
- B. Store the control panel indoors in a clean, dry, heated storage facility until ready for installation. Do not install the control panel in its final location until the facilities are permanently weather tight. Protect the control panel at all times from exposure to moisture, chemicals, hydrogen sulfide and chlorine gas.

1.07 PROJECT/SITE REQUIREMENTS

- A. The control panel shall consist of a main circuit breaker, a combination motor circuit protector (MCP), magnetic starter and overload relay for each motor, a 120 volt control power transformer with two fuses on the primary and one fuse on the secondary. All control components shall be mounted in one common enclosure. Control switches shall be provided to operate each motor either manually or automatically.

1.08 WARRANTY

- A. Manufacturer shall warrant equipment to be free from defects in materials and workmanship for a period no less than the controlled equipment warranty.

PART 2 PRODUCTS

2.01 RATING

- A. The control panel shall operate on a power supply as indicated on Drawings.
- B. The overall withstand and interrupting rating of the equipment and devices shall not be less than 42,000 amperes R.M.S, symmetrical at 480 Volts. All circuit breakers and combination motor starters shall be fully rated for the above fault current interrupting capacity. Series connected short circuit ratings will not be acceptable.

- C. The complete control panel assembly shall be UL certified or carry a UL listing for "Industrial Control Panels.
- D. The control panel shall meet all applicable requirements of the National Electrical Code.
- E. The control panel enclosure shall be in accordance with the electrical area classification indicated on the Electrical Contract Drawings.

2.02 COMPONENTS

- A. The main circuit breaker shall be a thermal-magnetic molded case breaker, Type FCL. Provide a flange mounted main power disconnect operating handle with mechanical interlock having a bypass that will allow the panel door to open only when the switch is in the OFF position.
- B. A mechanical disconnect mechanism, with bypass, shall be installed on each motor circuit protector, capable of being locked in the "OFF" position to provide a means of disconnecting power to the motor.
- C. Motor starters shall be provided with motor circuit protectors and equipped to provide under-voltage release and overload protection on all three phases.
 - 1. Motor starters shall be 2 or 3 Pole, 1 or 3-phase as required, 60 Hz, 600 Volt, magnetically operated, full voltage non-reversing except as shown on the Drawings. NEMA sizes shall be as required for the horse power shown on the Drawings.
 - 2. Each motor starter shall have a 120 Volt operating coil and control power transformer. Starters shall have motor overload protection in each phase. Auxiliary contacts shall be provided as shown on the Drawings. A minimum of one N.O. and N.C. auxiliary contacts shall be provided in addition to the contacts shown on the Drawings.
 - 3. Overload relays shall be adjustable ambient compensated and manually reset.
 - 4. Control power transformers shall be sized for additional load where required. Transformer primaries shall be equipped with time-delay fuses.
- D. Auxiliary contacts shall be provided for remote run indication and indication of each status and alarm condition. Additional controls shall be provided as specified herein, as required by the detailed mechanical equipment requirements, Division 16, Division 15 and as shown on the Drawings.
- E. All operating control devices and instruments shall be securely mounted on the exterior door. All controls shall be clearly labeled to indicate function and shall be in accordance with the electrical area classification indicated on the Electrical Drawings.
 - 1. Indicator lamps shall be heavy duty, 30 mm industrial type oil light, NEMA 4X, high-visibility LED, full voltage type. Units shall have screw on plastic lenses and shall have factory engraved legend plates as required. Unless otherwise specified in each equipment specification lens color shall be green for equipment OFF, red for equipment operating, blue for FAIL or ALARM and amber for power ON/Equipment Stand-by. For all control applications, indicator lamps shall incorporate a push-to-test feature.

2. Mode selector switches (HAND-OFF-AUTO, LOCAL-OFF-REMOTE, MOTOR SELECTOR, LEAD-LAG, etc) shall be heavy-duty 30 mm, NEMA 4X, oil tight, industrial type with contacts rated for 120 VAC at 10 Amps continuous. Units shall have standard size, white field, and legend plates with black markings, as indicated. Operators shall be black knob type. Units shall have the number of positions and contact arrangements, as required. Units shall be single-hole mounting, accommodating panel thicknesses from 1/16-in minimum to 1/4-in maximum.
 3. Push-button, shall be heavy-duty, 30 mm, NEMA 4X, oil tight industrial type with momentary or maintained contacts as required, rated for 120 VAC at 10 Amps continuous. Units shall have standard size, white field, and legend plates with black markings, as indicated. Button color shall be red for EMERGENCY STOP or START and green for STOP. Contact arrangement shall be as required.
- F. A six digit, non-resetable elapsed time meter shall be connected to each motor starter.
 - G. A failure alarm with horn and beacon light shall be provided as required by contract document. Silence and reset buttons shall be furnished.
 - H. The control panel shall be provided with a Surge Protective Device Unit on the load side of the main circuit breaker. Surge Protective Device shall be rated 65Ka per mode for all unit rated for 480V located outdoor.
 - I. An alternator shall be provided to sequence motors as required by contract document.
 - J. Intrinsically safe relays shall be solid state type with 5 Amp output contacts, suitable for use on a 120 Volt, 60 Hz power supply and shall be Factory Mutual approved for pilot devices in Class I, Division I, Group D hazardous atmospheres.
 - K. Control relays and timers shall be 300 Volt, 11-pin tubular, industrial rated, plug-in socket type, housed in a transparent polycarbonate dust cover, designed in accordance with UL Standard 508 for motor controller duty. Continuous contact rating shall be 10 Amps resistive, 1/4 Hp, at 120 VAC, with an operating temperature of minus 10 to plus 55 degrees C.
 - L. Panel mounted timers shall be SqD JCK70, flush mounted, plug-in type with ranges as shown on the Drawings, or as required by the detailed mechanical equipment specifications and Division 15.
 - M. Specific control devices, control descriptions and other data are specified under the detailed specification for the mechanical equipment with which the control panel is supplied.

2.03 ENCLOSURE TYPES

- A. The control panel specified herein shall be rated NEMA 4X enclosures and shall be constructed of 316 stainless steel.
- B. Enclosures shall be 14 gauge and constructed with continuously welded seams. The panel door(s) shall have continuous hinge and neoprene gasket. Door clamps shall be provided.

- C. The enclosure shall incorporate a removable back panel on which control components shall be mounted. Back panel shall be secured to the enclosure with collar studs. The enclosure door shall be interlocked with the main circuit breaker by a door mounted operating mechanism. Back panel shall be tapped to accept all mounting screws. Self-tapping screws shall not be used to mount any components.
- D. Print storage pockets shall be provided on the inside of the panel.
- E. Overload tables shall be laminated and adhered to the inside of the door.
- F. Enclosures located outdoors shall be painted white in the factory.

2.04 NAMEPLATES MARKINGS AND IDENTIFICATION

- A. Provide 2-in by 5-in, nominal, engraved phenolic master nameplate on the control panel fastened with stainless steel type 316 screws or rivets. Nameplate shall be black letters with white background, 3/8-in high lettering and shall indicate equipment designation as shown on the Drawing.
- B. Provide legend plates or 1-in by 3-in engraved nameplates with 1/4-in lettering for identification of door mounted control devices, pilot lights and meters.
- C. Provide permanent warning signs as follows:
 1. "Danger- High Voltage- Keep Out" on all doors.
 2. "Warning- Hazard of Electric Shock - Disconnect Power Before Opening or Working On This Unit" on main power disconnect.

2.05 CONDENSATION HEATERS

- A. A strip heater shall be mounted inside the control panel.
 1. Heater shall be rated 240V, but operated at 120V, single phase, 150 watts, with rust resisting iron sheath.
 2. A control thermostat mounted inside the control Panel.
 3. The strip heater terminals shall be guarded by a protective terminal cover.
 4. High temperature connecting lead wire shall be used between the thermostat and the heater terminals. Wire shall be No. 12 AWG stranded, nickel-plated copper with Teflon glass insulation.

2.06 WIRING

- A. Power and control wire shall be 600 Volt class, Type XHHW-2 insulated stranded copper and shall be of the sizes required for the current to be carried, but not smaller than No. 14 AWG. All wiring shall be enclosed in PVC wire trough with slotted side openings and removable cover.
- B. All interconnecting wires between panel mounted equipment and external equipment shall be terminated at numbered terminal blocks.
- C. All control panel wiring shall be numbered at both ends with type written heat shrinkable wire markers.

2.07 TERMINAL BLOCKS

- A. Terminal blocks shall be one-piece molded plastic blocks with screw type terminals and barriers rated for 600 volts. Terminals shall be double sided and supplied with removable covers to prevent accidental contact with live circuits. Terminals shall have permanent, legible identification, clearly visible with the protective cover removed. Each terminal block shall have 20 percent spare terminals, but not less than two spare terminals.
- B. Wires shall be terminated to the terminal blocks with crimp type, pre-insulated, ring-tongue lugs. Lugs shall be of the appropriate size for the terminal block screws and for the number and size of the wires terminated.
- C. Provide an AC ground bar bonded to the panel enclosure (if metal) with 20 percent spare terminals.
- D. Provide an intrinsically safe ground terminal bar isolated from the control panel enclosure. Provide 20 percent spare terminals but not less than two spare terminals.
- E. Terminal points for current transformer leads shall be provided with a shorting bar.

2.08 SHOP TEST

- A. Perform Manufacturer's standard production testing and inspection in accordance with NEMA and ANSI standards.

2.09 GENERATOR TERMINATION CABINET

- A. RATINGS
 - 1. The Assembly shall be rated to withstand mechanical forces exerted during a fault for current of 100,000 Amps.
 - 2. Voltage rating is 600 Volts.
 - 3. Amperage rating is 600 Amps
- B. Construction
 - 1. The service connection cabinet shall be a rigid assembly consisting of a base made of 12 gauge 316 stainless steel channels with 316 stainless steel.
 - 2. Bus bars shall be tin-plated copper.
 - 3. Enclosure shall meet the requirements of NEMA 4X.
 - 4. All hardware shall be 316 stainless steel.
 - 5. Enclosure bottom shall include a lockable drop door.
 - 6. Provide CAM Receptacles, two per phase.
 - 7. Enclosure is to be suitable for wall mounting.

EXECUTION

3.01 INSTALLATION

- A. Repaint any damage to factory applied paint finish using touch-up paint furnished by the control panel Manufacturer.

- B. Any work not installed according to the Drawings and this Specification shall be subject to change as directed by the ENGINEER. No extra compensation will be allowed for making these changes.

3.02 FIELD TESTING

- A. Check mechanical interlocks for proper operation. Make any adjustments required.
- B. Adjust motor circuit protectors and voltage trip devices to their correct settings.
- C. Install overload heaters per actual motor nameplate currents.
- D. Adjust motor circuit protectors for actual motor nameplate currents.
- E. In the event of an equipment fault, notify the ENGINEER immediately. After the cause of the fault has been identified and corrected, a joint inspection of the equipment shall be conducted by the CONTRACTOR, the ENGINEER and the control panel Manufacturer's factory service technician. Repair or replace the equipment as directed by the ENGINEER prior to placing the equipment back into service.

3.03 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 17000

INSTRUMENTATION GENERAL PROVISIONS

PART 1 GENERAL

1.01 SCOPE

- A. This section specifies the requirements for the Hornsby Bend Biosolids Management Plant Thickener Complex Rehabilitation project for the City of Austin. The requirements for the Process Instrumentation and Control System (PICS) outlined in this section address general hardware, software, and services necessary to provide the control functions specified. More detailed requirements of specific functions and components are presented in other Division 17 sections that follow.
- B. There are four parties that will be involved in this contract:
 - 1. OWNER: The City of Austin
 - 2. Design Engineer: ENGINEER who designed this project and provided the Specifications and Drawings.
 - 3. SCADA Programming Engineer: The Engineer who will provide SCADA PLC/HMI program service.
 - 4. Contractor: The Contractor who will supply and install all equipment in this contract
- C. Contractor is mainly to supply and install equipment and instruments specified in this contract document. Contractor also provides the supplied equipment and instruments test and startup, and required submittal, as-built and test reports, Owner Manuals, and other documents.
- D. SCADA PLC and HMI configuration and programming service will be provided by the City's SCADA service Contractor (SCADA Programming Engineer).
- E. The Contractor shall coordinate with the SCADA Programming Engineer on project schedule, installation, test, and startup services.

1.02 DEFINITIONS

- A. The definitions of terminology used in the Division 17 specifications or in any Section referencing Division 17, shall be as defined in ISA Standard S51.1 unless otherwise specified. Where terms used are not defined in ISA 51.1 or in these specifications, ANSI/IEEE Standard 100-1984, ANSI/ISA S50.1 or other ISA standards shall apply.
 - 1. Signal Circuit: Any circuit operating at less than 80 volts AC or DC.
 - 2. Control Circuit: Any circuit operating at 24 volts AC or DC or more, whose principal purpose is the conveyance of information and not the conveyance of energy for the operation of an electrically powered device.
 - 3. Power Circuit: Any circuit operating at 12 volts (AC or DC) or more, whose principal purpose is the conveyance of energy for the operation of an electrically powered device.
 - 4. Two-Wire Transmitter: A transmitter which derives its operating power supply from the signal transmission circuit and therefore requires no separate power supply

connections. As used in this specification, two-wire transmitter refers to a transmitter which provides a 4 to 20 milliampere current regulation of signal in a series circuit with an external 24 volt direct current driving potential and a maximum external circuit resistance of 600 ohms.

5. Electrical Isolation: Pertaining to an electrical node having no direct current path to another electrical node. As used in this specification, electrical isolation refers to a device with electrical inputs and/or outputs which are galvanically isolated from ground, the device case, the process fluid, and any separate power supply terminals, but such inputs and/or outputs are capable of being externally grounded without affecting the characteristics of the device or providing a path for circulation of ground currents. The terms "galvanic isolation," "electrical isolation", "isolation", or similar terms shall mean electrical isolation whenever used in Division 17, or whenever used in specifications for electrical control and instrumentation equipment in any other Divisions of these contract documents. Unless otherwise specified, electrical isolation for analog signal devices shall be rated 250 volts AC continuous; and 1500 volts AC for one minute, in accordance with ANSI/IEEE C39.5-1974.
6. Panel: An instrument support system which may be a flat surface, a partial enclosure, or a complete enclosure for instruments and other devices used in process control systems. Unless otherwise specified or clearly indicated by the context, the term "panel" in these contract documents shall be interpreted as a general term which includes flat panels, enclosures, cabinets and consoles.
7. Data Sheets: Data sheets as used in this specification shall comply with the requirements of ISA S20.
8. Field: When used to refer to locations at the treatment facility or in the transmission system, shall mean all outdoor locations, as well as all process and equipment areas. Unless otherwise specified, all areas shall be considered "field" locations except for: administration and other office areas; control rooms; motor control centers and other electrical equipment rooms; dedicated HVAC rooms; and maintenance buildings.
9. Control Room: An environmentally controlled room intended for housing digital control equipment, computers, large control panels, etc., and generally intended to be regularly occupied by operators.
10. Division 17 Work: Whenever the terms "Division 17 work", "specified under Division 17" or "provided under Division 17" are used, they shall be interpreted as referring to all materials, labor, products, services, systems, etc., specified in Specification Sections 17000 through 17920, inclusive, unless equipment shown or specified is clearly labeled as being provided under other parts of the contract.
11. UPS: Uninterruptible Power Supply.
12. HMI: Human-Machine-Interface. The control system hardware and software associated with providing the computer interface between system users and the control system.
13. PLC: Programmable Logic Controller. Field installed unit which monitors and controls devices, located within the plant. The PLCs contain all logic necessary to monitor and control the system process located at the PLC location.
14. SCADA: Supervisory Control and Data Acquisition.

15. RTU: Remote Terminal Unit. Field installed unit which monitors and controls devices, located away from the plant at remote locations. The RTUs contain all logic necessary to monitor and control the system process located at the remote location.
16. OIU: Operator Interface Unit.

1.03 REFERENCE STANDARDS

- A. This subsection references the latest revisions of the following standards. They are a part of Division 17 as specified and modified. In case of conflict between the requirements of this section and those of the listed standards, the requirements of this section shall prevail.

<i>Standard</i>	<i>Title</i>
ANSI/NEMA ICS 6	Enclosures for Industrial Control and Systems
API RP550	Manual on Installation of Refinery Instruments and Control Systems Part I – Process Instrumentation and Control
ISA S5.4	Instrument Loop Diagrams
ISA S20	Specification Forms for Process Measurement and Control Instrumentation, Primary Elements, and Control Valves
ISA S50.1	Compatibility of Analog Signals for Electronic Industrial Process Instruments
ISA S51.1	Process Instrumentation Terminology

1.04 WARRANTIES, MAINTENANCE, AND SUPPORT SERVICES

- A. Corrective Maintenance
 1. The Contractor shall provide the services of factory-trained service technicians for the purpose of performing corrective maintenance on all system hardware and software. The period of coverage for each piece of equipment shall begin upon initial equipment purchase or manufacture and shall continue as referenced under Section 00810 – Supplemental General Conditions or until expiration of the Manufacturer's warranty, whichever period is longer.
 2. The Contractor shall provide a 24-hour, 7-day/week service hotline for telephone notification of system malfunctions. Within 2 hours from notification by the OWNER of defective Control System operation, the Contractor shall have a qualified service representative establish telephone contact with the OWNER's maintenance personnel to discuss short-term corrective measures. If it is not possible to correct the defective operation as a result of the telephone contact, the Contractor shall have a qualified service representative at the location of the installed Control System within 24 hours from initial notification. The service representative shall perform all necessary inspections and diagnostic tests to determine the source of the defect and to establish a corrective action plan. The corrective action plan shall

be developed such that the defect is corrected as quickly as possible and with the least impact on the operation of the OWNER's facilities. Prior to beginning any repair or replacement procedure, the Contractor shall review the corrective action plan with the OWNER in order to inform OWNER of the planned course of action and to allow assessment of any impact that course of action might have on the operation of the OWNER's facilities. At OWNER's option, OWNER maintenance personnel may participate in any corrective maintenance procedures.

3. If possible, the service representative shall effect replacement or repair of the defective component before leaving the site using replacement parts from the spare parts inventory delivered with the system. Otherwise, the corrective action plan shall include a detailed schedule for the planned course of action. Once the defect has been corrected, the corrective action plan shall be updated indicating the source of the defect and specific corrective action taken. A copy of the updated corrective action plan shall be delivered to the OWNER on the day the work is performed. Any spares from the onsite supply of spares used by the Contractor in correcting the system malfunction shall be replaced within 15 days.
4. If 24-hour response time is not provided, or other corrective maintenance requirements are not met by the Contractor, the OWNER shall have the right to obtain corrective maintenance from other sources and charge the Contractor reasonable costs of the alternative maintenance services, including parts, labor, travel, and subsistence.
5. The OWNER, at the OWNER's option, may elect to employ its own maintenance staff to locate and remove a defective component. In this case the OWNER will return the defective component to a repair location as instructed by the Contractor. The Contractor shall repair or replace the defective component and return the properly working unit to the OWNER within 15 days.

1.05 CONTRACTOR'S QUALIFICATIONS

- A. The Contractor shall perform all work necessary to select, furnish, configure, customize, debug, install, connect, calibrate, and place into operation all hardware and software specified within this section and in other sections as listed in Article 1.02, Related Work.
- B. The Contractor shall be a "systems house," regularly engaged in the design and the installation of computer systems and their associated subsystems as they are applied to the municipal water or wastewater industry. For the purposes of this specification section, a "systems house" shall be interpreted to mean an organization that complies with all of the following criteria:
 1. Employs a registered professional Control Systems Engineer or Electrical Engineer to supervise or perform the work required by this specification section.
 2. Employs personnel on this project who have successfully completed a manufacturer's training course on the configuration and implementation of the specific programmable controllers, computers and software proposed for this project.
 3. Has performed work of similar or greater complexity on at least three (3) projects within the last five (5) years and has implemented and completed at least one of these three projects with the proposed HMI software.

4. Has been in the water/wastewater industry performing the type of work specified in this specification section for the past five (5) continuous years.
- C. The following Instrumentation/Controls Contractors, listed in no particular order, have been pre-approved to provide all instrumentation and controls works except HMI configuration and programming service:
 1. Prime Controls
 2. Control Panels USA Inc.
- D. The Contractor shall maintain a fully equipped office/production facility with full-time employees capable of fabricating, configuring, installing, calibrating, troubleshooting, and testing the system specified herein. Qualified repair personnel shall be available and capable of reaching the facility within 24 hours.
- E. Actual installation of the system need not be performed by the Contractor's employees; however, the Contractor shall provide the on-site technical supervision of the installation.
- F. The Contractor shall furnish equipment which is the product of one manufacturer to the maximum practical extent. Where this is not practical, all equipment of a given type shall be the product of one manufacturer.

1.06 SUBMITTALS

A. General

1. Submittals shall be made in accordance with the requirements of this section, the requirements of Section 01300, and the requirements of individual Division 17 Sections. The Contractor shall submit to the OWNER technical data and Drawings for all equipment, materials, software, assemblies, and installations prior to fabrication and installation. All submittals shall be made in accordance with the submittal procedures and requirements in Section 01300. The Contractor shall be responsible for the accuracy and completeness of all submittals, including information and Drawings provided by other suppliers or SubContractors providing equipment, materials, software or services to the Contractor.
2. In all instances in which submittals are required by the Specifications, the Contractor shall not proceed with the associated work until the submittal has been Successfully Reviewed.
3. Each submittal shall be complete, with all required information provided together at one time, and submitted in a sequence that allows the OWNER to have all of the information necessary for checking and approving a particular document at the time of the submittal. The specified timing requirements for each submittal are minimum requirements. The Contractor Supplier shall be responsible for planning and making all submittals as necessary to avoid delays or conflicts in the work.
4. See Section 01300 for requirements on quantities of documents to be submitted for review. Once documents have been successfully reviewed, the Contractor shall issue them in the quantities shown in the table labeled "Documentation Requirements".

- B. Submittal Categories: Project submittals are divided into the following general categories:
1. Design Submittals
 2. System Documentation Submittals
 3. Testing Submittals
 4. Training Submittals
 5. The following paragraphs define the specific contents of each of these submittal categories. The requirements outlined for each of these submittals shall apply to all equipment and services specified in all sections of Division 17. Additional submittal requirements may be found in specific sections of Division 17.
- C. Design Submittals
1. Hardware Submittal
 - a. Product information shall include, but not be limited to: catalog cuts, data sheets, performance surveys, test reports, equipment lists, material list, diagrams, pictures, and descriptive material. The product information shall cover all items including mechanical devices, mounting components, wiring, terminal strips, connectors, accessories, and spare parts. The submittal information shall show the standard and optional product features, as well as all performance data and specifications.
 - b. Prior to commencement of manufacture (or shipment for stock items), the Contractor shall submit for review product information for all equipment and material specified in Division 17, or required to support equipment, or systems specified in Division 17. Specific requirements for the form and content of product information submittals are included in the individual section that defines the equipment requirements.
 2. Connection Diagrams
 - a. Connection diagrams shall show the placement, labeling and wiring of components within panels, cabinets and consoles. Components shall be shown arranged in the physical layout (not necessarily to scale) as it would appear to a person servicing the equipment. Connection diagrams shall include all internal wiring of the panel; this shall include AC and DC power wiring and multi-conductor cables from PLC card to rewired termination blocks. Wires shall be shown as a continuous line between their termination points. Each wire label designation shall be shown. The wire label designations on each end of a single wire must be identical. All wire termination point numbers shall be shown. Each wire color shall be shown. Signal and DC circuit polarities shall be shown. All jumpers, shielding and grounding details shall be shown.
 - b. The Contractor shall submit connection diagrams for all new panels, modified panels, cabinets and consoles. Connection diagrams shall be Successfully Reviewed prior to the start of panel assembly.
 3. Panel Fabrication and Layout Drawings
 - a. Panel fabrication drawings are scaled drawings that shall show the physical dimensions, materials, and construction of panels, cabinets, terminal boards, consoles, or other electrical or mechanical equipment enclosures. These drawings show the physical arrangement and mounting of all components in or on a panel, terminal board, cabinet, console, or enclosure. These drawings

show the physical dimensions, and the space and mounting requirements of mechanical, electrical, control and instrumentation devices or pieces of equipment. Other information provided may include ventilation requirements, locations of connections, weight, and paint color, material and dry film thickness.

- b. As a minimum, panel fabrication and layout drawings shall include a bill of materials; front, back, and section views; the locations of all components to be mounted in or on the panel, cabinet, console, enclosure or assembly; drawing scale; nameplate engraving schedule; and structural materials and supports. All drawings shall be scaled. Overall dimensions and minimum clearances shall be shown. Sufficient detail shall be included to demonstrate material choices, outward appearance, construction methods, and seismic force resistance.
 - c. Complete shop drawings shall be prepared and submitted for all panels, cabinets, and consoles which are custom fabricated or modified for this project. The OWNER shall have the right to make modifications to the interior and exterior layouts of panels as part of the shop drawing review. No additional compensation will be provided to the Contractor for changes that result. The Contractor shall include in the bid price one redesign of the panel layout to incorporate the OWNER's modifications to the locations of specified components in or on each panel, cabinet, console, or enclosure.
- 4. Interface Cables: The Contractor shall submit for review interface cable pin-out/cable makeup diagrams. This includes all network cables, radio to PLC/RTU cables, computer to PLC cables and printer cables. Submittal shall include copies of the actual hardware documentation. All cables shall either be standard cables from the Manufacturer or custom-made, without the use of gender changers, 9-25 pin converters, null modem adapters, etc.
 - 5. Interconnection Diagrams: Interconnection diagrams shall include typical wiring diagrams for each type of product. Wires shall be shown as a continuous line between their termination points. Each wire label designation shall be shown. The wire label designations on each end of a single wire must be identical. All wire termination point numbers shall be shown. Each wire color shall be shown. Signal and DC circuit polarities shall be shown. All jumpers, shielding and grounding details shall be shown.
 - 6. Installation Drawings: Installation drawings shall show installation arrangements for all provided equipment, mounting and anchoring details, conduit entries into cabinets, and Control System electrical power supply distribution conduit and wiring. Data sheets and/or catalog cuts for mounting devices, anchors, wire and other incidental installation materials shall be included.

D. System Documentation Submittals

- 1. Operation and Maintenance (O&M) Manuals: The Contractor shall supply O&M manuals for all the equipment and software provided. The O&M manuals shall be developed for personnel at the level of electronic technician. The O&M manuals shall describe the detailed preventive and restorative procedures required to keep the equipment in good operating condition. An O&M manual or a set of manuals shall be furnished for all deliverable hardware, including OEM equipment. O&M manuals for OEM equipment shall contain original printed materials, not copies, and

may be provided in the Manufacturer's original format. Manuals shall be provided in electronic format. The O&M manuals shall contain the following information:

2. Instruction Manual
 - a. The manual shall be written in English and illustrated in detail to the component level, including assemblies, subassemblies, and components. It shall contain a detailed analysis of each major component so that maintenance personnel can effectively service, inspect, maintain, adjust, troubleshoot, and repair the equipment.
 - b. Each manual shall include a Table of Contents, arranged in systematic order, and shall be divided into the following sections:
 - (i) Introduction: The purpose of the manual, special tools and equipment, and safety precautions.
 - (ii) General Information and Specifications: A general description of the equipment item, and specifications of its major components.
 - (iii) Listings: Supplier's name, address, and telephone number. Each product shall include name, address, and telephone number of SubContractor, or installer, recommended maintenance Contractor, local source for replacement parts.
 - (iv) Theory of Operation: The relationship of assemblies, subassemblies, components and interchangeability of components, and explanation and analysis of their functions to the smallest board replaceable components.
 - (v) Software: Listing and explanatory text for any software or firmware.
 - (vi) Operation Procedures: The locations and functional descriptions of all controller indicators, or CRT displays.
 - (vii) Troubleshooting: A list in tabular format of all symptoms, probable causes of malfunction or improper operation, and probable remedies to the smallest board replaceable components.
3. Preventive Maintenance Instructions: These instructions shall include all applicable visual examinations, hardware testing, and diagnostic hardware/software routines. Instructions on how to load and use any test and diagnostic programs and any special or standard test equipment shall be an integral part of these procedures.
4. Corrective Maintenance Instructions
 - a. These instructions shall include guides for locating malfunctions down to the card-replacement level. These guides shall include adequate details for quickly and efficiently locating the cause of an equipment malfunction and shall state the probable source(s) of trouble, the symptoms, probable cause, and instructions for remedying the malfunction. These guides shall explain how to use on-line test and diagnostic programs for all devices and any special test equipment, if applicable.
 - b. The corrective maintenance instructions shall include:
 - (i) Explanations for the repair, adjustment, or replacement of all items, including printed circuit cards. Schematic diagrams of electrical, mechanical, and parts location, illustrations, photographs, and sectional views giving details of mechanical assemblies shall be provided as necessary to repair or replace equipment. Typical signal waveforms, logic levels, bit patterns, etc., shall be included. For mechanical items requiring

field repair, information on tolerances, clearances, wear limits, and maximum bolt-down torques shall be supplied. Information on the loading and use of special off-line diagnostic programs, tools, and test equipment as well as any cautions or warnings which must be observed to protect personnel and equipment shall be included.

- (ii) A list of test equipment and special tools required.
- (iii) A list of all abbreviations and circuit symbols used.
- (iv) Warranties, bonds and maintenance records, including proper procedures in the event of failures and instances which might affect the validity of warranties, bonds, or contracts.
- (v) A parts catalog enumerating every part to the lowest of card replaceable components. The description shall include component symbol, description, ratings, accuracy, Manufacturer's name and address, Manufacturer's part number, commercial equivalents, and quantity per assembly or subassembly. The parts catalog shall identify the appropriate locations of the parts and shall group each component by assemblies or subassemblies within each subsystem so that each component can be identified as being part of the next larger assembly.
- (vi) A list of recommended spare parts that includes all parts necessary to maintain and repair control system components. The list shall identify the specific part or model number, description, Manufacturer's name and address, commercial equivalents, unit price, lead time for delivery, and recommended quantity. The spare parts list shall indicate which components (by model and serial number) have been provided with the delivered system as part of the spares inventory.

5. Instrument Start-Up and Calibration Sheets

- a. Provide each instrumentation Start-Up and calibration sheet
- b. Instrumentation Calibration Sheet shall include each instrument configuration, each parameter setting, test result, test date, and signature.

6. Drawings

- a. O&M Manual drawings (with the exception of those provided by third-party Manufacturers) shall not be larger than 11-inches by 17-inches and shall be clearly legible when reproduced using conventional office copying machines. Originals shall be provided for all third-party O&M Manual materials. One reproducible of the O&M Manual drawing original must be supplied for each O&M Manual drawing larger than 11 inches by 17 inches, and must satisfy all drawing requirements specified herein. Those preprinted O&M Manual drawings which are not acceptable, or which must be modified or corrected to show the actual as-built design, shall be redrawn as new specially-prepared shop drawings. Acceptable equipment Manufacturer's drawings incorporated into equipment operating and maintenance manuals need not be duplicated or removed from the manuals.
- b. The Contractor shall furnish drawings in paper and latest AutoCAD electronic format.

- c. Each O&M Manual shall be bound in 8 1/2" x 11 inch 3-ring side binders with commercial quality hardback, cleanable plastic covers. Maximum of 3" binder size. O&M Manuals shall be submitted per Specifications Section 01730.
 - d. Binder covers shall contain the printed title "Operation and Maintenance Instructions", "City of Austin", "Hornsby Bend BMP Thickener Complex Rehabilitation". Submittal PDF format drawings and documents shall be searchable and book marked in each section
 - e. The manuals shall be internally subdivided with permanent page dividers with tab titling clearly printed under reinforced laminated plastic tabs.
 - f. Each volume shall have a Table of Contents, with each product or system description identified.
- 7. All parameters for electronic equipment shall be provided including all settings that are adjusted from default value.
- E. Software Manuals: The Contractor shall supply Original OEM O&M Manuals in lieu of developing specific O&M Manuals. Only that equipment which lacks proper O&M Manuals would the Contractor be responsible for supplementing the product literature.
- F. Record Documents
 - 1. After successful Site Demonstration Test, the Contractor shall submit for review the Record Documents (as-built) for all equipment and software installed by the Contractor. All documents which have changed because of the engineering changes, contract changes, or error or omission shall be updated and the revised documentation provided.
 - 2. The Contractor shall furnish complete as-built sets of:
 - a. Source tapes, disk pack(s) or other storage media for all custom programs
 - b. Loadable and executable object disk pack(s) of the software systems
 - c. All previously delivered documents, with as-built updates
 - d. OEM standard documentation.
 - 3. These media shall include the operating systems, all programs necessary for the operation as well as maintenance of the System, and all programs supplied by the CPU/Microprocessor Manufacturers, such as assembler, loaders, editors, compilers and diagnostics.
 - 4. The documentation as outlined in this portion of the document, in conjunction with other documentation specified elsewhere in this document, shall be sufficient to allow the OWNER to reconfigure or make additions or deletions to the System without assistance from the Contractor.
- G. Testing Documentation Submittals
 - 1. System test plan requirements are included in Specification Section 17000 part 3.
 - 2. Test procedures requirements are included in Specification Section 17000 part 3.
 - 3. Test reports requirements are included in Specification Section 17000 part 3.

Coordinate, schedule and submit accordingly advance notice to OWNER and ENGINEER for all testing and Start-Up.

PART 2 PRODUCTS

2.01 INFORMATION ON DRAWINGS

- A. The following information is indicated on the Drawings:
 - 1. Loop diagram on flow sheet for each control loop. Diagrams are schematic in nature and intended only as a guide to work to be performed.
 - 2. Approximate location of primary elements, instrument panels and final control elements.
 - 3. Approximate location of instrumentation power junction boxes for instrument electrical power connection.
 - 4. Location of electrical distribution panel boards for instrument electrical power.
 - 5. Location of equipment having alarms and equipment status contacts.
 - 6. Location of equipment being controlled by system.
 - 7. General layout of instrument cabinets.
 - 8. Instrument installation details.
- B. The following information is not shown on Drawings but shall be the responsibility of the Contractor to determine, furnish and coordinate with other divisions, based upon systems specified. Show this information on project record drawings.
 - 1. Instrument loop drawings per ISA S5.4 minimum, desired and optional items.
 - 2. Location of electrical distribution panel boards supplying power to any device supplied under this contract.
 - 3. Detailed enclosure and instrument panel layouts, fabrication details and wiring diagrams.
 - 4. Detailed system configuration.
 - 5. Raceway and cable routing for instrumentation wiring.

2.02 OPERATING CONDITIONS

- A. Ambient Conditions: Provide equipment suitable for ambient conditions specified. Provide system elements to operate properly in the presence of radio frequency fields produced by portable RF transmitters with output of five watts operated at 24 inches from instruments; in the presence of plant telephone lines, power lines and electrical equipment; and in the presence of digital data transmission systems.
- B. Field Locations: Field equipment may be subjected to ambient temperatures from -5 to 50°C with direct radiation, relative humidity from 0 to 100 percent with condensation.
- C. Power Supply: Power supply will be 117 volts AC, single- phase, 60-hertz commercial power. Voltage variations will be at least plus or minus 8 percent. Certain loops shall have integral power supply as indicated on the Drawings.

2.03 TRANSIENT AND SURGE ISOLATION

- A. Protect all power and communication and transmission/ receiving circuitry from any surge, including spikes up 1,000 volts peak and surges with a rise time of less than one microsecond. Use a combination of current limiting resistors, zener diodes, gas tube

surge arresters and a fusible link which melts and shorts the surge to ground before the device circuitry is affected. Provide protection adequate for personnel safety, which will prevent an erroneous output, change in calibration or failure of component other than fuse or fusible link.

2.04 SPARE PARTS

- A. During the system warranty period, the Contractor is expected to make system repairs by initially replacing the defective component with one from the spares inventory. The Contractor shall then replace the spare component

2.05 SPECIAL TOOLS

- A. Contractor shall supply one of each type of special hand tool required to open or operate equipment, to remove or replace replaceable parts, remove or replace cable connectors, or to make required operational or maintenance adjustments. A special hand tool is any tool not readily available from local retail hardware stores.

2.06 TEST EQUIPMENT

- A. The Contractor shall provide a complete list of all tools, test equipment, and commercial software programs necessary for the proper maintenance of the system. This list shall contain the quantity recommended, model number, description, cost, and name and address of supplier.

2.07 MATERIALS AND EQUIPMENT

- A. Materials: Material shall be new, free from defects, and of the quality specified. All instruments with the same specification shall be from the same Manufacturer.
 - 1. Provide equipment of solid-state construction utilizing second source semiconductors, unless otherwise specified. Derate components to assure dependability and long-term stability. Provide printed or etched circuit boards of glass epoxy, hand or wave soldered, of sufficient thickness to prevent warping. Coat printed circuit boards in field-mounted equipment with plasite 7122, or approved equal, to protect against corrosion. Alignment and adjustments shall be non-critical, stable with temperature changes or aging and accomplished with premium grade potentiometers. Do not insert components of specially selected values into standard electronic assemblies to meet performance requirements. Use parts indicated in instruction manuals, replaceable with standard commercial components of the same description without degrading performance of completed assembly. Do not use silver edge connectors or pins.
 - 2. Use test equipment and instruments to simulate inputs and read outputs suitable for purpose intended and rated to an accuracy of at least five times greater than the required accuracy of device being calibrated. Such test equipment shall have accuracies traceable to the National Bureau of Standards as applicable.
 - 3. Make equipment located in hazardous areas suitable for applicable classification by use of explosion-proof housings or equipment and barriers approved as "intrinsically safe" by either UL or FM. Locate barriers in cabinets at hazardous area boundaries. Use dual barriers in loops in order to prevent a grounding loop at the barrier.

4. Provide all special tools necessary for operation, maintenance and calibration of all (instruments) devices, subsystems, and systems supplied.

2.08 SPECIAL PROJECT REQUIREMENTS

- A. As a part of this contract, the instrumentation systems Contractor shall coordinate with all the sub-systems suppliers and Manufacturers, during bidding, construction, testing, installation and Start-Up phases of the project. The coordination is to assure that the instruments, and sub-systems are in compliance with the specifications and the central controls, and that the tie-ins and the interface signals are provided as required.
- B. The calibration, testing and Start-Up of all the instruments shall be done by the Manufacturer's field technician/ENGINEER in the presence of the OWNER. The Contractor shall provide a list of all Manufacturers whose technician will perform this work. The Contractor shall also provide a certified calibration report stating that each instrument has been installed per Manufacturer's recommendations and per these specifications.

PART 3 EXECUTION

3.01 OVERVIEW

- A. In this arrangement, each party has certain responsibilities.
 1. The Design ENGINEER is responsible for the following areas:
 - a. Review Contractor and SCADA Programming Engineer Submittal
 - b. Respond Contractor and SCADA Programming Engineer RFI (Request for information)
 - c. Witness all tests and Start-Ups: FDT, ORT, and PAT
 - d. Contractor and SCADA Programming Engineer Owner Manual review
 2. The Contractor is responsible for the following areas:
 - a. Acquisition and installation of all the hardware, software and instrumentation as defined in this specification and Drawings.
 - b. Provide equipment and instrument submittals
 - c. Perform the Factory Demonstration Test (FDT)
 - d. Perform Operational Readiness Test (ORT)
 - e. Perform Performance Acceptance Test (PAT)
 - f. Provide all instrument calibration and calibration documents
 - g. Provide Start-Up installation services for the PLCs.
 - h. Provide equipment and instrument trainings
 - i. Provide Owner and Manual
 3. The SCADA Programming Engineer is responsible for the following areas:
 - a. Provide SCADA PLC/HMI configuration, programming, and Start-Up services.
 - b. Perform the Factory Demonstration Test (FDT)
 - c. Perform Operational Readiness Test (ORT)
 - d. Perform Performance Acceptance Test (PAT)
 - e. Provide SCADA program training

- f. Provide SCADA Programming and Configuration Owner Manual
- 4. The OWNER is responsible for the following areas:
 - a. Review Contractor and SCADA Programming Engineer Submittal
 - b. Review Design ENGINEER RFI response
 - c. Witness all tests and Start-Ups: FDT, ORT, and PAT
 - d. Review Contractor and SCADA Programming Engineer Owner Manual

3.02 SYSTEM TEST REQUIREMENTS

A. General Requirements:

1. The Control System shall undergo a comprehensive system test process to demonstrate that the system performs as an integrated unit to meet the requirements of this specification. The Contractor together with the SCADA Programming Engineer, as a normal course of system development, shall conduct all element, subsystem, and system tests necessary to ensure the proper operation of the control system at various stages of system development.
2. The Contractor shall wire and test all spare I/O points.

B. Factory Demonstration Test (FDT)s

1. Joint effort between Contractor & SCADA Programming Engineer, a FDT and verification for all equipment, software, and associated documentation shall be performed prior to system, subsystem, or major components shipment. The tests shall be performed to verify that the equipment is manufactured and assembled correctly, is operating as designed, and is in compliance with the contractual requirements for the deliverables. The tests shall be performed to verify that the software and hardware will meet the functional and performance requirements of this document.

The OWNER (two persons) and the Design ENGINEER (one person) will witness and participate in these factory tests. If the FDT is held outside of Austin, Texas, the Contractor shall provide the following for the OWNER and the Design Engineer.

1. Air travel to/from the test facility
2. Lodging in a hotel
3. Ground transportation
4. Meals

The Contractor shall provide the following for the OWNER and the Design Engineer.

1. Notification four weeks in advance of the tests
 2. Above items if retesting must be performed to obtain satisfactory results
2. The FDT shall demonstrate compliance to each explicitly stated requirement in the specification. The FDT shall include I/O testing, communication testing, and PLC testing. The Contractor shall use the Excel spreadsheet program to build a FDT cross reference table that lists each specification paragraph that imposes a uniquely identifiable technical requirement. The Contractor shall add to the format a data field for the FDT test number of the test that is going to demonstrate compliance with the requirement. A second version of the table, sorted by test number, shall also be printed. This will make it possible to select any specification paragraph and identify the FDT test that should demonstrate the feature. The version ordered by

test number can be used to verify the completeness of each test and shall be used during the FDT to check off the features demonstrated.

3. The FDT shall include the following:
 - a. Equipment Test and Verification: The FDT for the equipment (hardware) shall include individual end-item verification and integrated tests of all hardware. These tests shall include visual inspection verification and running the standard hardware diagnostic programs, plus all special diagnostic programs used by the Contractor to demonstrate that the hardware integration task has been completed.
 - b. System Functional Test: The functional test shall exercise every specified system function and shall include, but not be limited to, the following:
 - (i) Rigorous exercising of all devices both individually and collectively.
 - (ii) Verification of proper scanning and data acquisition of status and data points.
 - (iii) Demonstration of all required data base management functionality.
 - (iv) Demonstration of all required software support utilities.
 - (v) Demonstration of all system diagnostics, both on-line and off-line.

3.03 OPERATIONAL READINESS TEST (ORT) AND START-UP

- A. Operational Readiness Test (ORT): Operational Readiness Test shall be a joint effort between Contractor and SCADA Programming Engineer. ORT and Start-Up shall consist of a sequence of activities and tests conducted as the control system components are installed and integrated at the job site. Following is a description of the individual steps that are involved with field testing and cut-over.

1. PLC Checkout
 - a. Once all PLC network are operational to each PLC location which included PLC network, and local PLC network, field installation and checkout of the PLCs will begin.
 - b. The field devices will be exercised by the Contractor to demonstrate the field wiring has been terminated properly.
 - c. Led by SCADA Programming Engineer, the next step of PLC checkout shall be Multilin and other devices communication to the PLC. Test all I/O or data exchanges from Multilin to PLC, and PLC to top-end SCADA. PLC checklist shall include communication with Multilin, and other devices.
 - d. Next, any control software associated with the PLC shall be activated and tested one-function at a time by the SCADA Programming Engineer and witnessed by the OWNER. When problems are found, the software configuration shall be "debugged" and the problem fixed by SCADA Programming Engineer with the Contractor assistance. When a problem is found, the appropriate tests shall be repeated after the problem is corrected by the SCADA Programming Engineer to verify proper operation. Once the control software in the PLC has been tested and debugged, that PLC shall remain online on the new control system.
 - e. Each PLC in the system shall be installed and tested using the procedure described above. A specific installation and start up plan shall be developed by the Contractor and SCADA Programming Engineer prior to Factory

Demonstration Test. The OWNER/Design ENGINEER will provide assistance as necessary in developing the Start-Up plan.

- f. During the Start-Up phase, the Contractor shall provide a minimum of 2 people on site full-time and one person in the field to support installation and testing activities.
2. Loop Testing
 - a. Contractor to provide individual instrument loop diagrams per ISA Standard S5.4 -Instrument Loop Diagrams, expanded format, to the Design ENGINEER for review prior to the loop tests. The Contractor shall notify the Design ENGINEER of scheduled tests a minimum of 30 Days prior to the estimated completion date of installation and wiring of the system. After the Design Engineer's review of the submitted loop diagrams for correctness and compliance with the specifications, loop testing shall proceed. The loop check shall be witnessed by the Design ENGINEER and SCADA Programming Engineer.
 - b. Contractor and SCADA Programming Engineer shall test each I/O from field to top-end SCADA.
3. Control Valve Tests
 - a. Control valves, cylinders, drives and connecting linkages shall be stroked from the operator interface units as well as local control devices and adjusted to verify proper control action, hand switch action, limit switch settings, torque settings, remote control actions, and remote feedback of valve status and position. Control valve actions and positioner settings shall be checked with the valves in place to insure that no changes have occurred since the bench calibration.
4. Interlocks
 - a. Hardware and software interlocks between the instrumentation and the motor control circuits, control circuits of variable-speed controllers, and packaged equipment controls shall be checked to the maximum extent possible.
5. Instrument and Instrument Component Validation
 - a. Each instrument shall be field tested, inspected, and adjusted to its indicated performance requirement in accordance with its Manufacturer's specifications and instructions. Any instrument which fails to meet any Contract requirement, or, in the absence of a Contract requirement, any published Manufacturer performance specification for functional and operational parameters, shall be repaired or replaced, at the discretion of the Design Engineer.
6. Loop Validation
 - a. Controllers and electronic function modules shall be field tested and exercised to demonstrate correct operation. Control loops shall be checked under simulated operating conditions by impressing input signals at the primary control elements and observing appropriate responses of the respective control and monitoring elements, final control elements, and the Operator Interface Unit. Actual signals shall be used wherever available. Following any necessary corrections, the loops shall be retested. Accuracy tolerances for each analog network are defined as the root-mean-square (RMS) summation of individual component accuracy requirements. Individual component accuracy

requirements shall be as indicated by Contract requirements or by published Manufacturer accuracy specifications, whenever Contract accuracy requirements are not indicated. Each analog point shall be tested by applying simulated analog or discrete inputs to the first element of an analog network. For networks which incorporate analog elements, simulated sensor inputs corresponding to 0, 25, 50, 75, and 100 percent of span shall be applied, and the resulting element outputs monitored to verify compliance to calculated RMS summation accuracy tolerance requirements.

7. Loop Validation Sheets

- a. The Contractor shall prepare loop confirmation sheets for each loop covering each active instrumentation and control device except simple hand switches and lights. Loop confirmation sheets shall form the basis for operational tests and documentation. Each loop confirmation sheet shall cite the following information and shall provide spaces for sign-off on individual items and on the complete loop by the Instrumentation Supplier:
 - (i) Project Name
 - (ii) Tag Number, Description, Manufacturer, and Model Number
 - (iii) Installation Detail Number
 - (iv) Specification Section Number
 - (v) Space for Comments
 - (vi) Space for Loop Sign-Off by Contractor and Date
 - (vii) Space for ENGINEER Witness Signature and Date
 - (viii) Loop Certifications
- b. When installation tests have been successfully completed for individual instruments and separate analog control networks, a certified copy of each test form signed by the Design Engineer, SCADA Programming Engineer and OWNER as a witness, with test data entered, shall be submitted to the Design ENGINEER together with a clear and unequivocal statement that the instrumentation has been successfully calibrated, inspected, and tested.

8. Pre-Commissioning

- a. Pre-commissioning shall commence after acceptance of wire test, calibration tests and loop tests, and inspections have demonstrated that the instrumentation and control system complies with Contract requirements. Pre-commissioning shall demonstrate proper operation of every system with process equipment operating over full operating ranges under conditions as closely resembling actual operating conditions as possible.

9. Pre-commissioning Procedures and Documentation

- a. Pre-commissioning and test activities shall follow detailed test procedures and check lists accepted by the Design Engineer. Test data shall be acquired using equipment as required and shall be recorded on test forms accepted by the Design Engineer, which include calculated tolerance limits for each step. Completion of system pre-commissioning and test activities shall be documented by a certified report, including test forms with test data entered, delivered to the Design ENGINEER with a clear and unequivocal statement that system pre-commissioning and test requirements have been satisfied.

10. System Testing

- a. When the PLC installation has been certified and Loop Testing has been completed, system testing shall be performed in accordance with the approved test procedures. Led by the SCADA Programming Engineer with support from the Contractor, system testing shall operate the various systems of the facility to verify compliance with all functional requirements specified, including the automatic control modes and PLC interlocks described in the control strategies contained in Section 17920. Tests which fail to demonstrate the required operation shall be repeated in their entirety or continued after corrective action has been completed at the discretion of the OWNER. Where feasible, System Testing shall include the use of water to establish service conditions that simulate, to the greatest extent possible, normal final control element operating conditions in terms of applied process loads, operating ranges, and environmental conditions. Final control elements, control panels, and ancillary equipment shall be tested under Start-Up and steady state operating conditions to verify that proper and stable control is achieved using motor control center and local field mounted control circuits. Hardwired and software control circuit interlocks and alarms shall be operational. The control of final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits. The stable steady state operation of final control elements running under the control of field mounted automatic analog controllers or software based controllers shall be assured by adjusting the controllers as required to eliminate oscillatory final control element operation.
- b. The transient stability of final, control elements operating under the control of field mounted, and software-based automatic analog controllers shall be verified by applying control signal disturbances, monitoring the amplitude and decay rate of control parameter oscillations (if any), and making necessary controller adjustments as required to eliminate excessive oscillatory amplitudes and decay rates.

11. Loop Tuning

- a. Electronic control stations incorporating proportional, integral or differential control circuits shall be optimally tuned, experimentally, by applying control signal disturbances and adjusting the gain, reset, or rate settings as required to achieve a proper response. Measured final control element variable position/speed setpoint settings shall be compared to measured final control element position/speed values at 0, 25, 50, 75, and 100 percent of span and the results checked against indicated accuracy tolerances.

12. On-Site Supervision

- a. The Contractor shall furnish the services of an on-site resident ENGINEER to supervise and coordinate installation, adjustment, testing, and Start-Up of the Contractor. The resident ENGINEER shall be present during the total period required to effect a complete operating system. A team of Engineering personnel shall be at the Site for 80 hours, in addition to on site time required in other specifications, to check equipment, perform the tests indicated in this Section, and furnish Start-Up services.

B. Performance Acceptance Testing (PAT)

- 1. Subsequent to Start-Up (and prior to issuance of Final Acceptance), the Contractor and SCADA Programming Engineer shall conduct a 14-day final acceptance test for

the entire system. In the test, the entire pump station control equipment and communication subsystem shall be continuously operated and maintained (i.e., 14 days continuous, 24 hours per day) during the test period with zero downtime resulting from system failures. If a system failure occurs, the 14 day test shall be considered a failure and not acceptable. The Contractor and SCADA Programming Engineer shall repeat the 14 day test. The system shall be acceptable only after all equipment and software has satisfied the performance test requirements.

2. In addition to the commissioning requirements of Section 01650, the Contractor and SCADA Programming Engineer shall furnish support staff as required to operate the system and to satisfy the repair or replacement requirements.
3. If any component fails during the performance test, it shall be repaired or replaced and the performance test shall be restarted at time zero for another 14 day period.
4. Downtime resulting from the following shall be considered system failures:
 - a. If a component or software issue that cannot be repaired/replaced within 4 hours.
 - b. Downtime in excess of 4 hours resulting from any I/O component failure.
 - c. Downtime resulting from concurrent failure of 2 or more I/O components in a single PLC.
 - d. Downtime of any component/peripheral associated with the communication network if the failed component (1) results in disabling or significant retardation of the control system network communications; (2) results in failure of pump station PLC control; (3) results in communications failure to/from the existing SCADA system; and (4) the failed component is not repaired or replaced within 4 hours.
5. The Contractor and SCADA Programming Engineer shall submit a final performance test completion report which shall state that all contract requirements have been met and which shall include; (1) a listing of all equipment maintenance/repair activities conducted during testing and; (2) a listing of all components which were unable to operate successfully.
6. After acceptance of all required performance tests, the Contractor shall be responsible for furnishing the spare parts/tools on site. All spare parts/tools stored on-site shall become the property of the City upon completion of the guarantee period. The Contractor and SCADA Programming Engineer shall guarantee that the completed system shall perform all of the data acquisition/logging, control/monitoring, and trending/reporting functions as shown and specified.

3.04 TRAINING

A. General

1. The Contractor shall train the OWNER's personnel on the maintenance, calibration, and repair of instruments and equipment provided under this Contract.

B. The SCADA Programming Engineer shall provide the following training:

1. Control System General Familiarity and Control Screen Functionality, provided onsite, Duration: two sessions and each 4-hour training
2. PLC and SCADA HMI Programming, provided onsite, Duration: one session and each 4-hour training

- C. The Contractor shall provide the following training:
1. All provided instrumentation Configuration, Operation and Maintenance, provided onsite: two sessions and each 2-hour training. Contractor shall divide training time equally between flow, level and gauge pressure applications.
 2. GE iFix HMI software training
 - a. Provide GE iFix HMI software training for following classes:
 - (i) Class 1 (iFix 134): HMI/SCADA iFix Fundamentals for 8 people
 - (ii) Class 2 (iFix 254): HMI/SCADA iFix Advanced for 8 people
 - b. Training class shall be at Austin Water facility. Coordinate with Austin Water for training class facility location
 - c. Provide training submittal for Austin Water to review. The submittal shall include
 - (i) Training schedule
 - (ii) Trainer resume
 - (iii) Course outline
 - (iv) Training equipment/laptop list
 - (v) Training Instruction Book
 - d. All training shall be provided by GE or GE Authorized Representative.
- D. Instructions
1. The training shall be performed by qualified representatives of the Contractor or ENGINEER and shall be specific to each piece of equipment. Training identified as Schneider Electric courses shall be conducted by Schneider Electric.
- E. Schedule
1. Training shall be performed during the pre-commissioning phase of the project. The training sessions shall be scheduled a minimum of 3 weeks in advance of when the courses are to be initiated. The Design ENGINEER will review the course outline for suitability and provide comments that shall be incorporated.
- F. Agenda
1. The training shall include operation and maintenance procedures, trouble shooting with necessary test equipment, and changing set points, and calibration for that specific piece of equipment.
- G. Documentation
1. Within 10 Days after the completion of each session the Contractor shall submit the following:
 2. A list of OWNER personnel who attended the session.
 3. A copy of the training materials utilized during the lesson with notes, diagrams, and comments.

3.05 CRITERIA FOR SUBSTANTIAL COMPLETION

- A. For the purpose of this Section and all Division 17, the following conditions shall be fulfilled before the system is considered substantially complete:
1. All submittals have been completed and approved.

2. All equipment has been calibrated, loop tested, and pre-commissioned.
3. The OWNER training has been performed.
4. Spare parts, special tools, expendable supplies and test equipment have been delivered to the OWNER.
5. FAT, ORT, PAT and RAT have been successfully completed.
6. Punch-list items have been corrected.
7. Record drawings in both hard copy and electronic format have been submitted.
8. Revisions to the O&M Manuals that may have resulted from the field tests have been made and reviewed.
9. Debris associated with installation of instrumentation has been removed.
10. Probes, elements, sample lines, transmitters, tubing, and enclosures have been cleaned and are in like-new condition.

3.06 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 17300

PROGRAMMABLE LOGIC CONTROLLER (PLC) REQUIREMENTS

PART 1 GENERAL

1.01 SCOPE

- A. Provide the PLC systems as shown on the design plans. The Contractor shall be responsible for providing a complete and operational system for the new and upgraded PLCs specified on the Drawings. These provided PLCs shall include hardware supply and installation.
- B. The Contractor shall provide the PLC hardware for the locations and requirements identified on the Drawings. This shall include all PLC equipment, programming software, cables, connectors, PLC/PC network interface cards, rewired termination blocks, fiber optic cable, PLC data highway cable, PLC Ethernet equipment, and any other hardware and/or software to ensure a fully operational system.
- C. The Contractor shall provide installation services for all provided PLCs. This service shall include removing the existing PLCs, installing new panel and new PLC hardware, panel rewiring, I/O points check, and PLC testing.
- D. The Contractor shall provide two complete sets of as-built drawings for each PLC panel. These drawings shall be complete and accurate. All PLC improvement changes or modifications shall be shown on the as-built drawings. Each set of drawings shall be provided in both paper and editable electronic PDF format and AutoCAD (latest version) copy.

1.02 SUBMITTALS

- A. Product Data:
 - 1. Submit vendor specification information along with a corrected copy of applicable specification form for each scheduled device specified in this section.
 - 2. Submit vendor specification information for each material and unscheduled device specified in this section.

1.03 WARRANTY

- A. Reference specification 17000.

1.04 TRAINING

- 1. N/A

1.05 SPARE PARTS AND TOOLS

- 1. The Manufacturer shall provide the specified spare parts and/or tools as detailed below:
 - a. One CPU of each type provided for the project configured to support the largest memory capacity used by the project.
 - b. One of each type of digital (DI & DO) I/O module used on the project.

- c. Two of each type of analog (AI & AO) I/O module used on the project.
- d. One of each type of network interface used on the project.
- e. One of each type of serial communication interfaces used on the project.
- f. One of each PLC power supply used on the project.
- g. One of each type of DC power supplies used on the project.
- h. One of each type of PLC rack used by the project.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. All new PLCs shall be from one PLC Manufacturer. PLC I/O modules shall be selected within one I/O product family.
- B. The panel layouts are for reference purposes only. In all cases, the Contractor shall verify that their PLC supplied will fit and operate properly in the space provided.
- C. The PLCs provided shall be self-contained units capable of collecting data through electrically dry relay contacts, 4 to 20 mA DC analog, high level AC input signals. The PLCs shall also be capable of providing AC and DC control outputs, both momentary and latching, the contacts of which will be used by OWNER for remote control. The Contractor shall provide all interposing relays that may be required to interface with the field AC signals.
- D. The PLCs shall have standalone calculation and control capability to perform the control logic functions using software and setpoints downloaded from the HMI.
- E. The Contractor shall upgrade to the latest firmware version available from the equipment manufacture. Some example of the equipment needed firmware upgrade included but not limited to, PLC CPU modules, communication modules, Ethernet switches, I/O modules, communication gateway.

2.02 PLC DESIGN REQUIREMENTS

- A. General
 - 1. Approved PLC Manufacturers are as follows:
 - a. Schneider Electric Model: PLC M340 for LPU-1 PLC
 - 2. The PLCs shall be solid-state electronic units of programmable design. The PLCs shall have a stand-alone restarting capability, i.e., no reloading of software programs for common logic, communications, and I/O processing at the PLC shall be required to resume operation following a loss of power. Therefore, all PLC basic programs shall reside in battery backed up RAM with at least a five- year battery life.
 - 3. The product line used shall have an expected product life of over ten (10) years. Products nearing the end of their life cycle are not acceptable. Contractor shall submit statement from Manufacturer as part of the submittal.
 - 4. Solid state RAM shall be utilized for data buffering, change of state information, calculation parameters, and local control algorithms. A power failure indication shall

be reported to the HMI after recovery from a power failure so that status initializing may be initiated by the HMI.

5. All electronic components shall be mounted on plug-in printed circuit cards or modular subassemblies. Each printed circuit card and subassembly shall be model and serial numbered to uniquely identify it. Printed circuit cards shall be plug-in with quick disconnect field terminations.
6. As a minimum the PLC CPU board shall have LED's for run, CPU fail, and low battery. The I/O modules shall have a power present LED.
7. Equipment shall be sufficiently sturdy to withstand handling during shipment, placement, and Start-Up without damage or distortion.
8. All switches and breakers and other current interrupting devices shall be non-arcing or hermetically sealed.
9. The PLC components shall be sized by the following tables, and used for this project. Any deviation from the table must be approved by the City.
10. Provide following module for LPU-1 PLC. Back plane shall be BMEXBP1200

<u>Slot No.</u>	<u>Description</u>
---	BMXCPS3500
0	BMXP342020
1	BMXNOC0401
2	BMXAMM0600
3	BMXAMM0600
4	BMXAMM0600
5	BMXAMI0810
6	BMXDAI1604
7	BMXDAI1604
8	BMXDAI1604
9	BMXDRA0805
10	BMXDRA0805
11	BMXDRA0805

B.

B. PLC Common Logic: Logic functions shall be implemented to receive data from and transmit data to the network, perform address decoding and error checks, and transfer data to and from the point input/output logic. In conjunction with the other PLC logic elements, the following functions shall be performed:

1. Respond to commands for retrieving data.
2. Prevent selection of more than one control point in a command sequence.
3. Protect against single component failures causing a malfunction.
4. Inhibit relays from being energized erroneously during the initial power-up period of the PLC.
5. Provide a "power fail bit" which will be set upon commercial power loss or failure of the AC/DC power supply.
6. Protect against a missing or failed logic card causing a malfunction, damage to other logic, or false transmission to the HMI.
7. Protect against over/under voltage conditions from the OWNER's power source and/or the Contractor's power subsystem from causing malfunction, damage to logic, or false transmissions to the HMI.
8. Provide a "Change Summary" bit in the returned message to report status point changes on an exception basis (if all status is not returned on each scan).
9. Provide a real-time clock function.
10. Each PLC shall continually monitor its operation and shall shut down in case of failure that would cause faulty solution of logic. A running PLC shall identify communication failures, I/O assembly errors, I/O module errors, and CPU battery failure and shall report such faults to the HMI. Faults shall also be reported to the PLC test set whenever it is connected to a PLC. In addition, a PLC trouble alarm shall activate a discrete output if any diagnostic detects a failure or upon CPU failure.
11. Provide for Peer-to-Peer communication between the PLCs. The new PLCs shall be able to exchange information with the other PLCs using the Ethernet protocol. Use of the HMI servers to exchange the data is not acceptable.
12. Provide empty I/O modules with a door cover for all PLC empty slots.

C. PLC Hardware Requirements:

1. Shall communicate using Ethernet MODBUS TCP/IP to the City SCADA network.
2. No DIP switches shall be used in the PLC system. All I/O addressing shall be done in software and all module configuration details shall be supplied by the PLC controller.

D. I/O Modules: The following types of process I/O interface capabilities shall be provided for the PLC:

1. Discrete Input Requirements
 - a. The Contractor shall be responsible for the PLC interface with the status and alarm contacts. For the "dry" contacts, the RTUs shall sense the states of these contacts by applying a voltage and observing the extent to which current flows. This voltage shall be obtained from a separate, isolated power supply furnished by the Contractor. The maximum resistance of an OWNER's indication circuit, when closed, will be 1000 ohms. The minimum resistance of a OWNER's

indication circuit, when open, will be 50,000 ohms. The RTU shall support the use of either AC or DC sensing voltage.

- b. For DC sensing, the voltage applied across the OWNER's open contacts shall be in the range from 24 VDC (nominal) to 48 VDC (nominal). There shall be 2500 VDC isolation between input and I/O assembly bus, and between inputs.
 - c. For AC sensing, the voltage applied across the OWNER's open contacts shall be in the range from 80 VAC (nominal) to 130 VAC (nominal) with a frequency range from 47 hertz to 63 hertz. Single-ended and double-ended inputs shall be supported. There shall be 1500 VAC isolation between input and I/O assembly bus, and between inputs.
 - d. The minimum current flowing through the OWNER's closed contacts shall be two milliamperes. The maximum allowable contact sensing current shall be 20 milliamperes.
 - e. Each status indication input shall be filtered for contact bounce and isolated from high electrical noise. A valid status shall be defined to be a state which is stable for a time period of 10 milliseconds.
 - f. The input modules shall have noise filters or use other techniques to reject short-time constant noise and 60-Hz pickup. Individual input point shall be capable of withstanding low energy common mode transients to 1,500 volts without catastrophic failure.
 - g. The input module shall have individual status light for each input and shall have barrier type terminal blocks for termination of the field wires. There shall be a minimum of 8 points per module. The module shall be constructed such that the field wires do not have to be removed while replacing the module. Surge protection shall meet ANSI/IEEE C37.90 requirements.
2. Discrete Output Requirements
- a. The discrete output logic shall process the control commands received from the common logic. Any control scheme, in which a single message with undetected errors can cause a false command, shall be unacceptable. All logic and point selection shall be reset with the reception of a "reset" command.
 - b. Discrete output drive circuitry shall be designed such that any single logic component failure in the PLC does not energize a discrete output.
 - c. A separate, clearly labeled Output Disable switch shall be provided to disable power to all discrete outputs simultaneously for testing.
 - d. An RTU status input shall be provided to indicate the current state of the switch.
 - e. Discrete outputs shall be via isolated, double-ended, dry form C contacts or isolated, double ended triac outputs.
 - f. All discrete outputs shall be rated for 120 VAC or 30 VDC, 5 amps, continuous at 60 Hz, 140 degrees F ambient.
 - g. There shall be one fuse with blown fuse indicator per point. There shall be a minimum of 4 points per module.
 - h. Two types of discrete output shall be provided by the RTU, programmable in the RTU software, as follows:
 - (i) Momentary Output - consists of those outputs which are closed for a preset time duration adjustable). A single timer for each RTU for all momentary outputs, adjustable from 0.1 to 15.0 seconds, shall be provided. If the

command is repeated before the timer has expired, the timer shall automatically reset for the full time period.

(ii) Maintained Output - consists of those outputs where the output remains in the energized state until a reset command is sent.

i. The output modules shall be protected from damage by inductively generated, NORMAL mode, and LOW energy common mode transients to 1,500 volts peak. The discrete outputs shall open when any single logic component failure is detected.

3. Analog Output Requirements

- a. The D/A converter shall have a minimum digital resolution of 12 bits and a relative accuracy of 0.1 percent of full scale, minimum.
- b. The analog output modules shall be 4-20 ma at 24 VDC; suitable for interfacing to regulatory final control elements or other analog devices.
- c. The analog outputs shall have the capability of being field-powered or being driven from the RTU's isolated 24 VDC power supply and shall drive a circuit of 600 ohms, minimum.
- d. The output shall be capable of driving a 1M ohm or greater load.
- e. There shall be a minimum of 4 points per module.

4. Analog Input Requirements:

- a. The A/D converter shall have a minimum digital resolution of 12 bits plus sign and a relative accuracy of 0.1 percent of full scale or better plus or minus the least significant bit.
- b. From the analog input to the digital output of the A/D converter, the overall accuracy shall 0.25 percent of full scale or better, including the effects of temperature over the specified ambient temperature range.
- c. Common mode noise rejection shall be at least 110 dB from 0 to 60 Hz.
- d. Differential mode noise rejection shall be at least 90 dB at 60 Hz.
- e. Input impedance shall be greater than 0.5 M ohms. The unit shall have overvoltage protection to withstand 150VAC without damage.
- f. Analog inputs from the transducers shall be 4-20 ma DC and all transducer power shall provide by the RTU 24 VDC power supply.
- g. Analog inputs shall be of the differential type capable of interfacing to two-wire loop power devices or four-wire field power devices. There shall be a minimum of 4 points per module.

E. PLC Power Supply:

- 1. PLC power supplies shall be supplied with 110 VAC. PLC power supplies shall contain a "Power OK" LED.
- 2. Power supply shall be sized to support the full complement of cards installed on the rack. The Contractor shall verify the power supply meets the requirements with all inputs and outputs fully-operational. For racks with unused slots, assume the empty slots contain the Analog Output module for power consumption purposes.

F. PLC Program Laptop:

- 1. Processor:

- a. A minimum of Intel Core Processor i7-10850H (6 Core, 12MB Cache, 2.70 GHz to 5.10 GHz, 45W, vPro)
2. Memory
 - a. 32GB, 2X16GB, DDR4 2933Mhz Non-ECC Memory
3. Hard drive:
 - a. Minimum M.2 512GB PCIe NVMe Class 40 Solid State Drive
4. Graphic Display
 - a. The integrated laptop display type shall be 15.6" FHD, 1920x1080, 60Hz, Anti-Glare, Non-Touch, 100% DCIP3, 500 Nits, WVA, CamMic/WWAN
5. Ports:
 - a. 2x USB Gen 2 Thunderbolt® 3.0 Type
 - b. 2x USB 3.2 Gen 1 with PowerShare
 - c. 1x HDMI 2.0
6. Video
 - a. Minimum of NVIDIA Quadro T2000 w/4GB GDDR6
7. Network
 - a. Intel® Wi-Fi 6 2x2 (Gig+) and Bluetooth 5.1
 - b. Integrated 10/100/1000 BASE-TX Gigabit Ethernet communication with RJ-45 port interface
 - c. Mobile Broadband: Qualcomm Snapdragon X20 LTE (DW5821e) AT&T
8. Software
 - a. Perpetual license Microsoft Office Suite latest version for each laptop
 - b. Latest version VMware Workstation Pro for each laptop
 - c. Operating system: Windows 10 Professional
9. Bag and Mouse
 - a. Nylon Deluxe backpack case sufficiently large to house the Laptop unit for each laptop
 - b. Logitech MX anywhere 3
10. Manufacturer: Dell Precision latest model
11. Quantity: Two (2)
12. Warranty: Five (5) year manufacturer's warranty covering parts and labor and next business day on site support as well as ProSupport and 3 Year CompleteCare Accidental Damage Protection

PART 3 EXECUTION

3.01 TEST REQUIREMENTS

- A. Factory Demonstration Test: The PLCs shall be integrated with the other components of the PLC system and tested as part of the system Factory Demonstration Test specified in Specification Section 17000. In addition to the general system test requirements, each PLC shall be subjected to the tests described in this section with a written confirmation of the test results.

- B. PLC Functional Test: Each PLC shall successfully pass the following functional tests to be performed in conjunction with the system Factory Demonstration Test, Site Demonstration Test, and Performance Testing:
1. A close and open operation on each control point, showing proper sequence of operations
 2. Verify the proper operation of the digital outputs
 3. A test showing that the proper indications are given at the HMI when one or more status input points change momentarily
 4. A series of communications tests showing all message protocols and formats to which the equipment is designed to respond, and demonstrating that all error-detection or error-correction capabilities function properly, and that the equipment does not respond to erroneous commands
 5. Telemeter readings of selected analog points to verify that the readings are within the specified accuracy when the inputs are at 0, 25, 50, 75 and 100 percent of full-scale
 6. A test showing that as a result of a scan request from the HMI, all requested analog, indication, and alarm points are transmitted from the PLC
 7. A test showing that the PLC successfully performs its various modes of operation while the power source for the PLC is varied over its specified range
 8. A test verifying that all common equipment, wiring, files, and power supplies are provided for expansion of the PLC to the ultimate point count specified. This test shall also verify that the power supplies are capable of carrying the increased load for this expanded point count.
 9. A test to verify the proper operation of the standalone capabilities of the PLCs.

3.02 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 17315

PLC NETWORK REQUIREMENTS

PART 1 GENERAL

1.01 SCOPE

- A. This section defines the requirements for Local Area Networks (LAN) to support the system interconnectivity required by the PLC portion of the distributed computing and control systems specified in other sections. The LAN network shall be seamlessly integrated with the systems as required to meet the system performance requirements.
- B. The CONTRACTOR shall include in the bid all security related LAN equipment as shown on contract Drawings. LAN equipment includes network switches, router, fiber optic patch panel, fiber optic patch cable, and Cat-6 patch cable needed. LAN equipment shall not include access control controller, digital video recorder, UPS associated with the security control panel or any security related devices. Some LAN equipment will be installed inside the security control panel. Security contractor shall provide panel design, all LAN equipment, and security equipment mounting inside the security control panel. Instrumentation contractor shall provide security contractor LAN equipment physical dimension, spacing requirement, and power requirement.
- C. The CONTRACTOR shall be responsible for the following equipment:
 - 1. Industrial Ethernet switch with minimum ports requirement listed in section below.
 - 2. All fiber-optic patch cables needed.
 - 3. All Cat-6 patch cables needed.
 - 4. Fiber optic cables.
 - 5. Fiber optic patch panel.
 - 6. Router.

1.02 SUBMITTALS

- A. The following items shall be furnished in the submittal package for this section:
 - 1. Data sheets and catalog literature for the fiber optic cable, the industrial Ethernet switches, the fiber optic transceivers, and the proposed fiber optic patch panels, terminations and connectors.
 - 2. Manufacturer specifications and data which clearly and unambiguously show that the cable meets all of the requirements specified herein.
 - 3. Samples of the specified cable and of the proposed terminators and connectors.
 - 4. Drawings showing the physical dimensions of all products to be furnished.
 - 5. Identification and labeling of cable, cable fibers, and cable terminations.
 - 6. Detailed network riser and connection diagram.
 - 7. Rack-up drawings of all equipment.
 - 8. A list of all network equipment used to make up the LAN and software provided with each.

9. Testing sequence, expected duration and schedule for the network test.
10. Network equipment, cable and system test documentation forms.
11. A list of the personnel who will be conducting the network equipment, cable and system testing, and their qualifications.

1.03 WARRANTY

- A. Reference specification 17000.

1.04 SPARE PARTS AND TOOLS

- A. Maintenance Materials (Extra Stock): Spare parts shall include the following minimum renewal parts in original packaging complete with wiring diagram and installation guide:
 1. Five 10 feet Ethernet Cat-6 molded patch cables.
 2. Two of each type of fiber-optic molded patch cables used.
 3. One Ethernet cable Cat-6 crimp.
 4. Five hundred feet of Cat-6 cable.
 5. 100 Cat-6 crimp connectors.
 6. One of each type of Ethernet switch used.
 7. One of each type of router used.
 8. One of each router module used.
 9. One of each SFP module used.

PART 2 PRODUCTS

2.01 NETWORK CONFIGURATION

- A. The System Network consists of a Local Area Networks (LANs) for PLC and SCADA HMI. Refer to the Drawings for the overall network:
 1. All necessary LAN interconnecting hardware and cables shall be included with the system. The CONTRACTOR shall coordinate LAN cable lengths and equipment locations with the OWNER and shall be responsible for the total connectivity of the equipment utilizing the LAN. The fiber optic cables shall be terminated in patch panels located in each security enclosure.

2.02 LAN NETWORK FUNCTIONS

- A. General Requirements:
 1. All necessary information shall be transmitted by the system network to and/or between the following, all PLCs, various other processors connected to the system, all control subsystems, and peripherals.
 2. The LANs shall utilize Ethernet.
 3. The LANs shall support installation in facilities where RFI/EMI noise is commonly experienced. The LAN's shall be designed to provide efficient and secure data transfer under these conditions.
 4. All Cat-6 network connections shall be provided with surge protection at both ends of any runs where the cable leaves a building.

5. In no case shall the LAN fail to meet the data transmission rates and throughput required to meet the system performance requirements for any function defined in this Specification.
 6. Each LAN shall have data transmission speeds of a minimum of 100MB. The CONTRACTOR shall be responsible for meeting all system performance requirements using these communications links.
- B. Local Area Network Requirements: The LANs shall comply with the Ethernet specification and shall support connectivity between all LAN resident devices. The CONTRACTOR shall provide all network equipment including cable, cable connectors, amplifiers, splitters, and communication cards required to make a complete and operational network.
- C. Network Configuration: Owner will configure all network switch settings.

2.03 NETWORK CABLES

A. Cat6 Cable

1. The RJ-45 cables shall be plenum-rated, Teflon-coated, and Category 6 (ANSI/TIA-568-B.2-1) cables. Standard RJ-45 quick connectors shall be provided to connect 10/100-BaseT network to LAN resident devices. The network patch bay will be Category 6 rated (ANSI/TIA-568-B.2-1) with punch down type connections on back side and RJ-45 connectors on the front. All patch connections to the hub shall be made to fit at the proper length (no oversized cables). All patch cables will be Category 6 rated (ANSI/TIA-568-B.2-1) and clearly labeled. The cable is designated Cat 6 Ethernet Wiring on Contract Drawings.
2. The wires shall be Belden 7953A.

2.04 NETWORK SWITCH

- A. Provide network switch as shown on I sheet. Provide all required hardware including DIN-rail mounted plate, brackets, and hardware in Network Rack.

PART 3 EXECUTION

3.01 TEST REQUIREMENTS

A. Cat.6 Cable Testing:

1. Each cable shall be tested for continuity on all pairs and/or conductors. Twisted-pair voice cables shall be tested for continuity, pair reversals, shorts, and opens using a "green light" type test set. Twisted-pair data cables shall be tested for the all of the above requirements, plus tests that indicate installed cable performance. These data cables shall be tested using a Level III cable scanner.
2. Continuity - Each pair of each installed cable shall be tested using a "green light" test set that shows opens, shorts, polarity and pair-reversals. Shielded/screened cables shall be tested with a device that verifies shield continuity in addition to the above stated tests. The test shall be recorded as pass/fail as indicated by the test set in accordance with the Manufacturers recommended procedures, and referenced to the appropriate cable identification number and circuit or pair

number. Any faults in the wiring shall be corrected and the cable re-tested prior to final acceptance.

3. Length - Each installed cable shall be tested for installed length using a TDR type device. The cables shall be tested from patch panel to patch panel, block to block, patch panel to outlet or block to outlet as appropriate. The cable length shall conform to the maximum distances set forth in the ANSI/TIA/EIA-568-B Standard. Cable lengths shall be recorded, referencing the cable identification number and circuit or pair number. For multi-pair cables, the longest pair length shall be recorded as the length for the cable.
4. Performance Verification - Category 6 data cabling systems shall be performance verified using an automated test set. This test set shall be capable of testing for the continuity and length parameters defined above, and provide results for the following tests:
 - a. Pair-to-Pair Near End Crosstalk (NEXT).
 - b. Power Sum Near End Crosstalk (PSNEXT).
 - c. Insertion Loss.
 - d. Return Loss.
 - e. Equal Level Far End Crosstalk (ELFEXT)
 - f. Power Sum Equal Level Far End Crosstalk (Power Sum ELFEXT).
 - g. Attenuation to Crosstalk Ratio (ACR).
5. Category 6 data cable shall be performance verified using an automated test set. Test results shall be automatically evaluated by the equipment, using the most up-to-date criteria from the ANSI/TIA/EIA-568-B.2.1 Standard, and the result shown as pass/fail. Test results shall be printed directly from the test unit or from a download file using an application from the test equipment Manufacturer. The printed test results shall include all tests performed, the expected test result and the actual test result achieved.

3.02 EQUIPMENT FABRICATION AND ASSEMBLY

- A. Cable Terminations: All cable terminations shall be through an industry standard interface which allows proper termination.
- B. Cable Runs:
 1. All cables in the Control System LAN shall be run inside a metal conduit, and in a manner which protects the cable from damage or electrical noise.
 2. Cables shall not be supported by their connections or terminations.
 3. Cables shall not run across hinges of doors or panels at 90 degree angles to the hinge or panel.
 4. All cables shall be protected from abrasion, multiple flexing at any one spot, and accidental snagging during maintenance.
 5. All connectors shall be keyed and allow the connection to fit only one way.
- C. Labeling
 1. All cables and connectors shall be labeled. The connector on the cable end and the receptacle into which the cable fits shall be labeled in a way which clearly identifies the proper cable and receptacle connection.

2. The length of each piece of cable shall be recorded on the cable tag and documented in tables or a data base on digital media. The location of each cable splice shall be documented on digital media. This information shall be included in the as-built drawings.

3.03 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 17325

UNINTERRUPTIBLE POWER SUPPLY

PART 1 GENERAL

1.01 WORK INCLUDED

- A. This section specifies the furnishing and installation of a complete uninterruptible power supply (UPS) systems for provided LPU-1 PLC panel. The UPS shall be minimum size of 1.5 KVA with dry-contract outputs for UPS fail and UPS battery fail signal.

1.02 REFERENCES

- A. ANSI
- B. NEMA
- C. UL
- D. NEC

1.03 SUBMITTALS

- A. Submit the following information to the ENGINEER for review:
 - 1. Shop drawings and product data.
 - 2. Installation instructions and wiring detail.
 - 3. Supplier shall certify that the equipment furnished meets or exceeds the VA capacity requirements of this section.
 - 4. Provide bypass switch dimension; installation instructions and wiring detail.
 - 5. Provide battery rack dimensions; battery type, size, dimensions and weight; detailed equipment outlines, weights and dimensions; single-line diagram indicating metering, control and external wiring requirements if required to meet the specified runtime.
- B. All other applicable requirements of Section 01300.

1.04 WARRANTY

- A. The manufacturer shall provide an all-inclusive two (2)-year warranty.

PART 2 PRODUCTS

2.01 SYSTEM RATING

- A. The equipment shall be sized to maintain a system continuous rating as shown on the table above.
- B. The UPS system shall be equipped with a battery. The battery shall be capable of supporting the load at rated voltage for a minimum protected period of 30 minutes.

2.02 ELECTRICAL CHARACTERISTICS

- A. The system shall be designed for a 120V, single phase input voltage at 60 hertz, with a 5% total harmonic distortion.
- B. The system battery shall be capable of operating a full load.
- C. The system shall be designed to deliver output voltage at 120 V, single phase, 60 hertz, with output voltage regulation of plus or minus 3 percent when on inverter.
- D. The overall system efficiency shall be 90% while line power is present.
- E. The UPS shall have full output isolation utilizing a low impedance isolation transformer design that safeguards against lightning and other high-energy surges without creating detrimental side effects. Must have a neutral/ground bond at the secondary of the transformer.
- F. The UPS shall be tested in accordance with and comply with the surge voltage withstand capabilities defined in ANSI/IEEE C62.41 Category A & B, 6KV/200 & 500 Amp. 100kHz ringwave.
- G. The UPS output wave on battery voltage shall be a sine wave.

2.03 BATTERY

- A. Batteries shall be sealed, maintenance-free lead acid with a 3-6 year typical lifetime.
- B. Batteries should be located in thermally isolated compartments or in separate battery modules to minimize battery degradation from heat generated by the UPS.
- C. Battery replacement design shall allow for hot-swap change-out of the battery packs without the necessity of turning off the UPS.

2.04 DESIGN AND CONSTRUCTION

- A. The UPS shall be housed in a freestanding cabinet unless otherwise specified. Provide 316 stainless steel racks for the UPS where the weight of the UPS does not rest on cabling at the bottom of the panel.
- B. Forced air cooling shall be provided to ensure all components are operated within their environmental rating.
- C. Rectifier/charger capacity shall be sufficient to supply full load to inverter while recharging fully discharged battery to 60 percent of full capacity in four hours or less.
- D. The UPS shall have a front panel display that is capable of displaying the percentage of UPS capacity in use, the percentage of battery runtime available during an AC line power failure and displaying various status codes.
- E. The UPS shall be provided with a software package capable of providing various real-time status and diagnostic functions.

- F. The UPS shall be provided with dry-contact to provide UPS fail and UPS battery fail signals to SCADA PLC for UPS failure condition SCADA monitoring. The dry contact shall be rated at least at 2A 120Vac.
- G. Mean time between failures of 60,000 hours, minimum.
- H. The audible noise level shall not exceed 60 db at 1 meter.
- I. Electroplate brackets and securing hardware with corrosion resistant material. Secure bolts, studs and nuts with lockwashers.
- J. Provide cabinet grounding lug.
- K. External By-Pass: Provide each UPS specified with an external bypass capable of removing the entire UPS for maintenance and replacement while maintaining power to the equipment.
- L. The provided UPS shall not be computer rack-mounted type.

2.05 MANUFACTURER

- A. Approved UPS manufacturers are:
 1. A P C (www.apc.com)
 2. Powerware (www.powerware.com)
 3. MGE (www.mgeups.com)
 4. Liebert (www.liebert.com)
 5. Alpha Technologies Model FXM (www.alpha.ca) for outdoor rated applications.
 6. Control Power Company Model LTN (www.controlledpwr.com) for outdoor rated applications.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install UPS where shown on the Plans and in accordance with manufacturer's instructions.
- B. Connect the alarm contacts to the digital inputs to alarm loss of power to the UPS, and failure of the UPS.
- C. Perform field inspection and testing; verify performance criteria; measure battery discharge and recharge times; simulate fault in each system component and utility power.
- D. Upon completion of the testing, the CONTRACTOR shall issue to the OWNER a letter of certification attesting to the fact that the system has been tested and adjusted and that it is in compliance with this specification.
- E. Two periodic inspections, at no expense to the OWNER, shall be made within the first year's guarantee period to ensure satisfactory operation of the system.

END OF SECTION

SECTION 17400

INSTRUMENT PANELS

PART 1 GENERAL

1.01 SCOPE

- A. The Contractor shall furnish, deliver, and install the control panels as shown on the drawings with power supplies, communications equipment, PLC Equipment, prewired termination blocks, incoming power surge suppression, and miscellaneous equipment to provide a fully functional system as shown on the drawings and specified herein.
- B. The control panels shown on the drawings are:
 - 1. PLC LPU-1
- C. This section specifies connection wiring within panel and electrical accessories such as switches, pilot lights, relays, terminal blocks, and fuses, which are included in the panel.
- D. All work and products shall conform to the designs shown on the applicable Drawings and shall comply with the provisions of this section. The control panel shall be factory wired. Panels and cabinet shall include all components indicated in the applicable Drawings, required to provide functions as specified in this section. Where specific requirements on the Drawings conflict with general design requirements in this section, the requirements shown on the Drawings shall prevail.

1.02 REQUIRED PANELS

- A. Panels shall conform to the layout shown on the Drawings, and be sized to accommodate the initial and future Input/Output (I/O) point counts listed shown on the Drawings. Enclosure sizing was based on typical industry-standard equipment. Contractor shall advise the Owner if a larger enclosure is required to meet these I/O counts using the actual equipment to be supplied by the Contractor.
- B. For each PLC CPU, provide a minimum of twenty percent spare wired I/O for each I/O type: analog input (AI), analog output (AO), digital input (DI), and digital output (DO).
- C. For each PLC remote I/O rack, provide a minimum of twenty percent spare wired I/O for each I/O type: analog input (AI), analog output (AO), digital input (DI), and digital output (DO).

1.03 QUALITY ASSURANCE

- A. All equipment and accessories provided shall be the product of a Manufacturer regularly engaged in manufacturing of this equipment whose products have been in satisfactory service for not less than three (3) years. Completed panels shall bear the UL label.

1.04 PANEL COMPONENT LAYOUT

- A. The Contractor shall generally follow the arrangements of components shown on the Contract Drawings. However, the Contractor shall make adjustments as necessary to

allow each component to be mounted as recommended by the Manufacturer, to facilitate easy installation, removal and in-place maintenance of each component, and to allow normal operation of the component by operating and maintenance personnel. Component arrangements shall allow space for routing of wiring without kinking or bending around sharp edges, and for free flow of air around and through equipment, which requires ventilation for cooling.

1.05 WARRANTY

- A. Reference specification 17000.

1.06 REFERENCE STANDARDS

- A. All materials and workmanship shall conform to the latest published applicable provisions of the following codes and standards:

<i>Standards</i>	<i>Title</i>
NFPA	National Electrical Code (NEC)
ANSI/NEMA ICS 1	General Standards for Industrial Controls and Systems
ANSI/NEMA ICS 2	Industrial Control Devices, Controllers, and Assemblies
ANSI/NEMA ICS 3	Industrial Systems
ANSI/NEMA ICS 4	Terminal Blocks for Industrial Control Equipment and Systems
ANSI/NEMA ICS 6	Enclosures for Industrial Controls and Systems
ANSI/NEMA 250	Enclosures for Electrical Equipment (1000 Volts maximum)
EIA RS-310-C	Racks, Panels, and Associated Equipment
ANSI-C-37.13	Low-Voltage AC Power Circuit Breaker (600 Volt Insulation Class)
ANSI/IEEE	Electrical Isolation for Analog Signal Devices C39.5-1974

- B. Unless otherwise specified, electrical equipment and material provided under this contract shall be listed and labeled for the purpose for which it is used by the Underwriters Laboratories, Inc. (UL). This requirement may be waived only if a UL listing is not available for the type of product.

1.07 SUBMITTALS

- A. General: The Contractor shall provide submittals as defined herein and as required in Specification Section 17000 – Instrument General Provisions. Submittals shall be required for all equipment supplied. For each panel, the Contractor shall submit a certified factory (shop) test report before panel is shipped.

- B. Elementary Control Diagrams: The Contractor shall provide elementary control diagrams, using the ladder diagram format incorporating line number, operation function statement, contact location line number with an underline for a normally closed contact and a description of operation of each device. Label each contact, coil, and indicator with its function, as well as its number. Show terminals for field wiring. Show field wiring as dashed lines.
- C. Panel Layout Diagram: Panel layout diagrams shall show the placement of components on the sub panel, side panel, panel outside doors, panel inside doors, and detail door cutout diagram. Each components show on the panel layout diagram shall have a unique item number corresponding to the Bill of Material (BOM) on the same drawing. At a minimum, the BOM shall include: item number, quantity, description, manufacture, and manufacture part number. The panel layout diagrams shall have sufficient information for a third party panel fabricator to fabricate the panel if needed.
- D. Connection Diagrams: Connection diagrams shall show the placement, labeling and wiring of components within panels and cabinets. Components shall be shown arranged in the physical layout (not necessarily to scale) as it would appear to a person servicing the equipment. Wires shall be shown as a continuous line between their termination points. The direction of entry to a wire bundle shall be shown. Wire lists and wireless diagrams shall not be accepted. All additions and deletions of devices and wires in existing enclosures shall be clearly shown. Each wire label designation shall be shown. The wire label designations on each end of a single wire must be identical. All wire termination point numbers shall be shown. Each wire color shall be shown. Signal and DC circuit polarities shall be shown. All jumpers, shielding and grounding details shall be shown. Wire pairs shall be shown. Spare wires and termination points shall be shown.
- E. Cables Pin-Out Diagram: Panel pin-out diagram shall contain pin-out of all cables including manufacture supplied cables needed for the panel construction, pin-out diagram shall include cables length, and connectors detail i.e. DB-9 Male, DB-25 Female, RJ-45. The cable pin-out diagrams shall have sufficient information for a third party cable fabricator to fabricate the cables if needed.

PART 2 PRODUCTS

2.01 CONTROL PANELS

- A. Physical and Miscellaneous Specifications: The enclosures shall:
 - 1. Be NEMA 4X carbon steel with 3 point latching handle.
 - 2. Contain PLC equipment, surge arresters, circuit breakers, fuses, relays, transformers, terminal strips, nameplates, terminal labels, wire ducts, universal spiral wraps and any necessary parts for a complete systems as shown on the drawings and specified herein.
 - 3. Be wall mount or free standing as shown on the drawings.
 - 4. Allow expansion space to accommodate future system needs.
 - 5. Pad-lockable

2.02 PANEL FABRICATION

- A. Materials: The enclosure shall be made with 12 gauge minimum steel. Each shall be provided with a full length interior panel with adjustable mounting on both vertical sides to rails located at the top, bottom, and middle of the enclosure.
- B. Acceptable Manufacturers:
 - 1. Hoffman Engineering Company
 - 2. Rittal (www.rittal.com).
- C. Dimensions: Panels shall be sized as shown on drawings.
- D. Coating:
 - 1. Sub-panel of all panels and cabinets shall be painted Fed. Std. color 27880, white.
- E. Face-Mounted Instrument Reinforcement: Face-mounted devices shall be mounted to panel doors using mounting methods recommended by the component Manufacturer with mounting kit parts provided by the component Manufacturer specifically for the component. If such a mounting method causes the door to deform or allows the component to sag so as not to be perpendicular to the door surface, then the Contractor shall design and install appropriate reinforcement to prevent these conditions.
- F. Cabinet Temperature Control: All cabinets shall have ample cooling to prevent high temperatures from shortening the life of the equipment. No location within the cabinet or interior of the equipment mounted inside shall reach temperatures higher than that specified for the equipment by the equipment manufacturer. Provide panel mounted air conditioner. Mounting of the panel mounted air conditioner shall retain the cabinet's NEMA rating. Acceptable manufacture: ISC (www.iscenclosurecooling.com), Kooltronic (www.kooltronic.com), or Noren (www.norenproducts.com). Provide heat load calculation for all equipment inside the control panel and demonstrate that the panel mounted air conditioning units provided have sufficient cooling power to maintain the panel internal temperature lower than that specified for the equipment by the equipment manufacturer. Obtain heat load information from equipment that is provided by others to correctly calculate the size of the panel mounted air conditioner.
- G. Miscellaneous:
 - 1. Face-mounted equipment shall be flush or semi-flush, with flat black escutcheons. Cutouts for future equipment and holes resulted from removal of existing devices shall be blanked off with suitable covers as required to retain the cabinet's NEMA rating. Component identification shall be hot ink stamped on the panel interior.
 - 2. All miscellaneous hardware and fittings shall be stainless steel. Stainless steel shall meet or exceed the corrosive-resistant properties of 316 stainless steel.
 - 3. Install large folding shelf on inside of door for test equipment or laptop. The large folding shelf material shall match the enclosure finish. The large folding shelf size shall be a minimum of 18.0" x 18.0".

2.03 NAMEPLATES

- A. Machine engraved, three ply laminated phenolic nameplates shall be provided for all panels and cabinets as shown on the Contract Drawings. Nameplates shall be white with black lettering. Nameplates shall be attached to the panel with a minimum of two self-tapping 316 stainless steel sheet metal screws. The height of each character shall be a minimum of 3/16" except as noted.

2.04 WIRING AND ELECTRICAL DEVICES

- A. General: Provide the wiring and electrical devices specified below and install these and internal panel wiring as shown on the Contract Drawings. All spare PLC input/output points shall be wired to terminal blocks with interposing relays and surge protection.
- B. Power Distribution:
 - 1. Unless otherwise specified, power for instrumentation equipment shall be obtained from a 120 volt, 60 hertz distribution panel-board in the Lighting Panel.
 - 2. Each cabinet shall be equipped with a 120 VAC main power disconnect circuit breaker, 120 VAC surge protection and power distribution circuit breakers as shown on the Contract Drawings. The main power disconnect breaker shall be a one pole breaker rated at the amperage shown on the Contract Drawings. Distribution circuit breakers shall be single pole rated at the amperage shown on the Contract Drawings. The circuit breaker shall be rated at 250VAC maximum with a short circuit rating of 10,000 amps for all breaker ratings. The circuit breakers shall be mounted on a standard DIN rail, and shall be Allen-Bradley Channel Mounting Type, or equal.
 - 3. For each power distribution circuit breaker, a neutral return terminal block shall be installed at the bottom of the breaker rail. The neutral return terminal block shall be standard DIN rail mounted, and shall be rated to carry required amperes and accept up to two 12 AWG wires. This terminal block shall conform to the requirements specified herein.
 - 4. Each cabinet shall be provided with din-rail mounted grounding type receptacle power outlets for 120 VAC power supply connections as shown. Each piece of equipment which is equipped with an ac power cord shall be plugged into a power outlet. For outdoor panels provided din-rail mounted receptacle with Ground Fault Interrupter (GFI). Phoenix Contact EM-DUO or approved equal.
- C. Panel Connection Wire and Cable:
 - 1. All cable furnished by the Contractor, including cable with any and all wires terminated at both ends within the same panel or enclosure and cable with any wires terminated at more than one panel or enclosure, shall conform to the requirements specified below:
 - a. Power and Control Cable – Power and control wiring shall be single conductor stranded copper NFPA 70 Type MTW. Power wiring from the main circuit breaker to distribution breakers shall be 10 AWG minimum. All other single conductor 120 VAC and 24 VDC power and common return wiring, common ground buses and all common logic bus circuits shall be 12 AWG minimum. All power cable shall be 12 AWG minimum. All power wiring shall be rated for 600V and 80°C.

- b. Single Conductor Wire – All single conductors used for PLC and control panel input/output and discrete control circuit wiring shall be No. 14 AWG tinned SIS conductor copper, all field wires exterior to panel shall be XHHW-2 cable. Cable shall be Belden, or equal.
 - c. Analog Signal Cable – Wiring for 4-20 milliampere, 1-5 volt DC signals and other analog signals shall be No. 16 AWG stranded copper twisted pair shielded cable, 80°C rated, UL listed, 0.25 inches maximum outside diameter, with 100 percent coverage aluminum foil mylar-lines shield and No. 22 AWG (minimum) stranded tinned copper drain wire, Houston Wire and Cable, Belden, or equal. Multi-pair analog signal cable shall be individually shielded (with drain wire) No. 16 AWG stranded conductor copper with a 100 percent aluminum/polyester foil shield with drain wire and an outer PVC jacket. The cable is designated TSP on the Contract Drawings. The cable shall be rated for 600V, 80°C (NEC Article 300-3).
 - d. Wire Tagging, all panel connection wiring shall be tagged at terminations with machine printed slip on type tags. The Contractor shall show wire/cable tag designations on all wiring diagrams submitted to the Owner. There shall be a tag placed within two inches of any wiring termination. The tag shall be fixed to the wire to prevent the tag from sliding more than two inches from the terminal as the result of gravity and vibration
 - e. All panel wirings shall use tinned type SIS cables. No multi-conductor cables are allowed for this project except twisted shielded or RTD cable.
2. Power and Control Circuits:
- a. Refer to Section 16200 – Wires, Conductors and Cable – 600V and Below.
 - b. Refer to Section 16205 – Wire and Cable Tagging.

D. Terminal Blocks:

- 1. Unless otherwise shown or specified, terminal blocks shall be captive screw with pressure plate, DIN EN 50035 rail 600 volt rating. Terminal blocks for Input/Output shall be prewired type as specified in Specification Section 17300 – Programmable Logic Controller (PLC) Requirements. Terminal blocks shall be the type specified in the following table, or equal:

<i>Description</i>	<i>Type</i>	<i>Application</i>
Terminal Block or equal	Phoenix UT 4-MTD	120 VAC, Neutral
Grounding Terminal	Phoenix UT 4-MTD-PE	Equipment Grounding Block
End Clamps	Phoenix E/NS 35 N	Each Group of Blocks
Terminal Marking	Phoenix ZB 6	All terminal Blocks as required
Terminal Strip Marker	Phoenix KLM-A	Each Group of Blocks
Insertion Strip	Phoenix FBS	As Required

2. Provide Phoenix Contact UT 4-HESIL fused disconnects with light indicators for 24VDC and 120VAC circuits with fuses as shown on the drawings (www.phoenixcon.com). Provide 20 fuses of each type as spares.
- E. Terminal Tags, Covers and Markers: Each terminal strip shall have a unique identifying alphanumeric code designation at one end and a plastic marking strip running the entire length with a unique number for each terminal. The Contractor shall assign terminal strip numbers from the number "1" and continuing in ascending cardinal order. The terminal strip designation shall be the letters "TB" followed by the terminal strip number. The strip and terminal point designations shall be machine printed and 1/8 inch high. Terminal blocks carrying 120 VAC power circuits shall be provided with a transparent, hinged cover for personnel protection and accessibility.
- F. Wire Routing: Wires shall be routed in slotted plastic wire-ways with snap covers. Wires carrying 120 VAC shall be separated as much as possible from other wires and signal cables, and shall be routed only in ducts shown on the Contract Drawings to be for 120 VAC. If the power wiring has to cross the signal wiring, the crossing shall be as close to a right angle as possible. Ducts shown for 24 VDC shall be used for all other wires and cables. Routing of 120 VAC in combined ducts shall be minimized. Wires and cable shall be routed along the shortest route between termination points, excepting routes which would result in routing 120 VDC and other wires and cables in the same duct. For intrinsically safe signal wiring refer to ANSI/ISA RP12.6 "Installation of Intrinsically Safe Instrument Systems in Class I Hazardous Locations." Wires and cables shall have sufficient length to allow slack and to avoid any strain or tension in the wire or cable. Wires and cables shall be placed in the ducts in a straight, neat and organized fashion and shall not be kinked, tangled or twisted together.
- G. Wire Terminations:
1. Single wire and cable conductors shall be terminated according to the requirements of the terminal device.
 2. For captive screw pressure plate and screw terminals, appropriately sized lugs shall be used. Lugs shall be crimp on type that forms gas tight connections. All crimping shall be done using a calibrated crimping tool made specifically for the lug type and size being crimped.
 3. On shielded cables, the drain wire shall be covered with insulating tubing along its full bare length between the cable jacket and the terminal lug or terminal pressure plate.
- H. Single Position Indicating Lights:
1. Single position indicating lights shall be 120 VAC, NEMA 4, heavy-duty, 33mm oil-tight, LED type. The lens color shall be as designated on drawings.
 2. Spare: provide five (5) each type of indicating lights.
- I. Control relays shall have 120-volt coils, 11 pin tubular octal bases with indicating light, and contacts rated for 10 amps. Furnish 1 N.O. and 1 N.C. spare contacts in addition to those required by the control scheme. Spare relays: provide five (5) each type of control relays

- J. Timing relays shall have 120 volt coils, 11 pin base, selectable for on delay or off delay functions, and settable for time delays of 0.05 seconds to 999 minutes with 10 amp contact rating. Relays shall be Square D class 9050 type JCK70 or equal. Spare relays: provide five (5) each type of timing relays
- K. Cabinet Lighting: Each panel shall be provided with LED light. Lights shall operate from 24 VDC, and shall be wired to power through a door-mounted switch, which shall be activated by opening the cabinet door, to be located and wired as shown. Cabinet lights shall be Hoffman cabinet light A80LT.
- L. Power Line Surge Protectors: Each panel shall be provided with a 120 VAC, 20 Ampere service power line surge protector. The surge protectors shall be heavy duty, multi-stage, and high speed. Response time shall be 5 nanoseconds maximum, and shall allow 340 Volts maximum peak surges to pass through. Protector shall be wired to the cabinet ground bar via a dedicated #8 AWG solid copper wire. The power line surge protectors shall be EDCO Type HSP-121 (www.edcosurge.com), or equal.
- M. Panel Ground:
 - 1. Each panel shall be provided with a 1 inch high x 0.25 inch thick solid copper grounding bus bar across the bottom of the panel. The grounding bar shall be mounted on insulated standoffs so that no electrical connection is made between the grounding bar and the cabinet through the mounting. The ground bar shall be drilled and tapped for a .25-20 screws at .5 inch intervals along its entire length.
 - 2. An uninstalled solid copper #8 AWG ground wire shall be attached between the ground bar and the panel enclosure, and between the ground bar and the mounting panel. The ground connection to the enclosure and panel shall be made by sanding the paint finish off a small area, drilling a hole for a .25 inch bolt and mounting a .25-20 bolt to the panel to serve as a grounding stud. The grounding stud shall be attached with a nut and flat washers on both sides of the enclosure/panel, and with an inside tooth star lock washer next to the panel surface. The star lock washer shall be on the inside surface of the enclosure, and the front surface of the mounting panel. The grounding wire shall be secured to the stud with a nut and inside tooth star lock washer. These grounding points shall be located within 12 inches of the bottom of the grounding bar.
- N. Power Supply: Each panel shall be provided with 24 VDC switching type power supplies connected in parallel via current steering diodes. These power supplies shall operate from 120 VDC input power and shall provide direct current output current of 10 Amperes at 24 VDC at 40°C, and shall be adjustable from 24 to 28 VDC by screw driver operated adjustment. Input power regulation shall be .2% from 105 to 130 VDC. Output load regulation shall be .2% maximum from zero to full load. Ripple shall not exceed .5% at full load. The power supplies shall have integral output current limiting and over voltage protection. The power supplies shall have fully enclosing cases. The power supply shall be manufactured by SOLA SFL series, or approved equal.
- O. Condensation Heater: Provide thermostatically operated condensation space heaters, which are sealed and safe to touch.

- P. Wiring Duct: Plastic wiring duct shall be slotted type with dust cover, Panduit type E or NE, as required.
- Q. Condensation and Pressure Compensation Devices: All indoor and outdoor non-freestanding enclosure install Hoffman Engineering Company stainless steel vent drain part number AVDR4SS4 or approved equal for metallic enclosure, and non-metallic vent drain part number AVDR4NM or approved equal for non-metallic enclosure.
- R. All field and panel control wires shall be labeled with wire ID. The wire ID tag shall follow the Owner wire tag naming convention. Coordinate with the Owner to obtain wire tag naming convention.

PART 3 EXECUTION

3.01 TEST REQUIREMENTS

- A. The Contractor shall shop test the panels and correct any defects discovered prior to delivery. These tests shall consist of the following:
 - 1. The Contractor shall verify that each wiring connection is made properly by checking electrical continuity, assuring that connections have less than one Ohm resistance end to end, and that no cross continuity exists between separate circuits.
 - 2. The Contractor shall conduct a test of all power circuits and power supply equipment to verify that proper voltages are delivered and all power supply equipment is operating according to the Manufacturer's specifications. These tests shall be witnessed by the Owner's Representative. The Contractor shall certify the results in writing to the Owner.
 - 3. The Contractor shall functionally test each electrical device specified in Part 2 to verify correct operation. Reference test procedures at section 17000 – Instrumentation General Provisions, and 17300 – Programmable Logic Controller (PLC) Requirements.
 - 4. The Contractor shall test Ground Fault Interrupter (GFI) receptacles and circuit breakers for proper operation by methods sanctioned by the receptacle Manufacturer.

3.02 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 17520

INSTRUMENTS

PART 1 GENERAL

1.01 SCOPE

- A. This section of instrumentation covers the following field instruments.

1.02 SUBMITTALS

- A. The submittals shall be as defined in Section 17000 – Instrumentation General Provisions.

1.03 JOB CONDITIONS

- A. Environmental Requirements: The equipment shall operate in ambient temperature 0-130°F, relative humidity 30-100%.
- B. Project power 120 volts, 60 hertz single-phase. Appropriate isolation shall be provided.
- C. Standard Signal:
 - 1. Output Signal. Each instrument, which outputs a signal, shall output the standard 4-20 mA signal. The signal shall be constant over a load range of 0 to 600 ohms.
 - 2. Input Signal.
 - a. Electronic devices, such as controllers, match function devices etc., shall have an input impedance of one mega-ohm minimum for an input signal of 1 to 5 VDC.
 - b. The 1 to 5 VDC signal shall be developed by the standard 4 to 20 mA transmitted signal through a precision 250 ohm, one-watt resistor.
 - c. These requirements allow several receiving units to monitor the same transmitting unit without causing any perturbation of the received signal.
 - d. Receiving devices shall not be wired in parallel.

PART 2 PRODUCTS

2.01 EQUIPMENT FURNISHED

- A. Refer to instrumentation sheets at the end of this Specification.

2.01 ELECTROMAGNETIC FLOW TUBE AND TRANSMITTER

- A. Type: Electromagnetic
- B. Requirements:
 - 1. Power Supply: 100-240VAC/24VAC/DC
 - 2. Output: Input: 4-20mA HART, pulse/frequency/switch output

3. Housing: Remote, aluminum, coated
 4. Cable, Remote Version: 100.00 ft coil + signal cable
 5. Electrical Connection: Thread NPT1/2
 6. Liner: Wastewater/Sludge application
 7. Calibration Flow: 0.2%, 3-point
 8. Customized Parameterization: Display; Totalizer
 9. Minimum accuracy required: +/- 1.5%.
 10. Ambient temperature: -5° – 140°F
 11. Suitable for flooded condition
 12. Sensor element shall be submersible rated
- C. Required Accessories and Options
1. Display unit: required and NEMA 4X enclosure.
 2. Surge Protection: Surge protector with 316 Stainless Steel connection
- D. Pipe size: per mechanical drawings showing pipe size.
- E. MANUFACTURERS and Models:
1. Rosemount Model: 8750WA
- F. Instrument list:

TAG	LOCATION	RANGE	UNIT
FIT-TC01-04A1	Centrifuge No. 1 Polymer Feed	0~1000	GPM
FIT-TC01-04A2	Centrifuge No. 2 Polymer Feed	0~1000	GPM

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
1. Install instruments in various locations in the field and on panels as shown on the drawings.
 2. All installations shall be in accordance with the Manufacturer's recommendations and instructions.
 3. All the necessary mounting accessories shall be provided.

3.02 SCHEDULE

- A. The instruments shall be supplied of the range and type as described in this section.

3.03 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 17600

SYSTEM CONFIGURATION

PART 1 GENERAL

1.01 SCOPE

- A. The SCADA Programming Engineer shall provide all application software programming and software programming related submittal to the Owner for all PLCs and HMI for this project. The SCADA Programming Engineer will program the PLC offsite using the hardware and software provided by the Contractor.
- B. Contractor to provide all tests with SCADA Programming Engineer. These tests include PLC IO check and test, equipment and field instrument status and reading test for both PLC and HMI, and PLC/SCADA network communication test.

1.02 ENGINEER SUBMITTALS

- A. PLC Control Strategy Submittal: The PLC Control Strategy submittal shall be a singular all-inclusive submittal which shall include a complete description of the PLC programs to be furnished, including modifications and explanation of how the specific functional requirement will be met. A cross reference between the specification and the software submittal shall be provided to allow the Owner to clearly identify how each specified section or function is being met by the PLC control strategy.
- B. Additional Requirements: The following items shall be submitted with the final sets of O&M Manuals.
 - 1. All application software submittals specified in this Section.
 - 2. All PLC program and HMI configuration program files. The PLC program and HMI configuration file disks shall also be updated as required if any changes or corrections are required in the programming prior to project completion.

PART 2 EXECUTION

2.01 HMI GRAPHICS GENERATION

- A. It is the responsibility of the SCADA Programming Engineer to configure the HMI and to develop, design, engineer, configure and test all of the graphic displays required for this project. All of this work shall take into account the specific needs of the end user. In order to facilitate this work the SCADA Programming Engineer shall conduct the following meetings with the Owner and Design Engineer:

Graphics Meeting No. 1

- 1. The SCADA Programming Engineer shall develop an agenda for a meeting which shall address the basic criteria to be adhered to in the configuration and development of HMI graphic displays. At this meeting the SCADA Programming Engineer shall distribute sample display formats for illustration purposes. As a minimum, this meeting shall address the following issues:
 - a. All facility conventions for identifying tag names and descriptors.

- b. Organization of the systems universal display hierarchy.
 - c. Paging schemes to be used to enable the movement from one display to another.
 - d. An itemization of the type of display to be used at each level in the graphic hierarchy (e.g., pre-formatted displays, templates, custom graphics, etc.).
 - e. Color convention to be employed on all graphics for the annotation of various status information, differentiation between alarms on the basis of alarm priority, background colors, static field colorization and dynamic field colorization.
 - f. The utilization of blinking and conditional text.
 - g. Definition of graphic symbolism to be used on the project. This listing shall include but not be limited to symbols to be used for process instrumentation, process equipment, piping, vessels and valves. All symbolism must be specific as opposed to generic in that shapes must define both function and type (e.g., specific symbols for each valve design, each pump design, each type of flow meter, etc.). If the SCADA Programming Engineer's library of shapes does not adequately describe plant or pipeline conditions, the SCADA Programming Engineer shall develop additional shapes to meet the plants or pipelines requirements.
 - h. Definitions of all display select commands that enable the operator to move within the display hierarchy.
 - i. The utilization of cursor movement commands which enable the operator to move within a display.
 - j. Definition of control input commands which enable the operator to interact with faceplate control stations and custom graphic displays to implement control outputs/functions.
 - k. Definition of data input commands which enable the operator to enter numeric values into the PLC system.
 - l. Definition of the utilization of "poke" points or fields which are dynamically sensitive to operator inputs to facilitate operator entry directly into graphic displays.
 - m. Security login/logout.
2. Subsequent to the adjournment of graphics meeting No.1 the SCADA Programming Engineer shall prepare and formalize a document titled "GRAPHICS CRITERIA" which shall contain detailed meeting minutes and a definition of all graphic guidelines to be adhered to. This report shall be supplemented by graphic examples which illustrate the incorporation and application of each graphic criteria. The report shall be submitted within 30 calendar days of the meeting's adjournment.

Graphics Meeting No. 2

1. Subsequent to the finalization of the overall system-wide graphics criteria, the SCADA Programming Engineer shall develop the project HMI graphics and demonstrate the graphics on a live running HMI during Graphics Meeting No.2. Graphics Meeting No.2 shall include the following:
 - a. A review of the graphic package for content and completeness.
 - b. A review of all data fields that display automatically updated process information.

- c. A review of all required input commands associated with the graphic access and control manipulation.
- 2. Subsequent to the adjournment of Graphics Meeting No. 2 the SCADA Programming Engineer shall prepare a formalized submittal of the graphic package for review along with the detailed meeting minutes. The report shall be submitted within 30 calendar days of the meetings' adjournment.
- B. The Owner shall allow eight hours for Graphics Meeting No.1 and four hours for Graphics Meeting No.2.
- C. The following HMI graphic displays shall be developed for this project (as a minimum). Some screens may be combined as directed by the OWNER during the graphics meetings:
 - 1. All required screens
 - 2. Alarm History
 - 3. Current Alarm Summary
 - 4. Historical Trending Displays (One trend for each analog value. Trends may be combined as directed by the OWNER during the graphics meeting).
- D. The SCADA Programming Engineer shall provide a description of the each control loop to be monitored and/or controlled by the system.

2.02 PLC PROGRAMMING

- A. It is the responsibility of the SCADA Programming Engineer to configure the PLC and to develop, design, engineer, configure and test all of the PLC Programming required for this project. All of this work shall take into account the specific needs of the end user. In order to facilitate this work the Engineer shall conduct the following meeting with the Owner:

PLC Programming Meeting No. 1

- 1. The SCADA Programming Engineer shall chair and develop an agenda for a meeting which shall address the basic criteria to be adhered to in the configuration and development of PLC programs. At this meeting the Engineer shall distribute sample PLC function blocks that will be used for this project. As a minimum, this meeting shall address the following issues:
 - a. All facility conventions for identifying tag names and descriptors.
 - b. Organization of the PLC program hierarchy.
- 2. Subsequent to the adjournment of PLC Programming Meeting No.1 the Engineer shall prepare and formalize a document titled "PLC PROGRAMMING CRITERIA" which shall contain detailed meeting minutes and a definition of all PLC programming guidelines to be adhered to. This report shall be supplemented by PLC programming examples which illustrate the incorporation and application of each PLC program criteria. The report shall be submitted within 30 calendar days of the meeting's adjournment.

2.03 FACTORY TEST

- A. General: The PLC's software factory test shall be provided in accordance with Section 17000.

PART 3 EXECUTION

3.01 PROGRAMMING, TESTING, AND INSTRUCTION

- A. General: The PLC's software calibration, testing, and instruction shall be provided in accordance with Section 17000.

3.02 GRAPHICS SCREENS

- A. HMI screens shall be configured to maximize user friendliness for the facility operators and mimic the Owner existing screen standard. The process of calling up a display screen shall consist of touching preconfigured targets on the current screen.
- B. The various required screens shall use text of all capital letters with the exception of certain engineering units. All text shall be horizontal. Screens showing equipment shall include the equipment number and name as used in the Contract Drawings. Total equipment run times shall be displayed as hours and tenths of hours adjacent to equipment symbols. Each screen shall show the current time and date which shall appear in the same place on each screen.
- C. Images and renderings shall be of suitable resolution so as to present a crisp image with no blurred outlines or borders at the selected HMI maximum screen resolution. Rendered, animated GIF files of like quality shall be developed and used to represent operating equipment wherever possible. Compressed graphic file formats (e.g. jpeg) and native vector images shall be used in order to reduce file size.
- D. The SCADA Programming Engineer shall configure graphics screens to display all status and analog data contained in the PLCs. The Contract Drawings, Control Strategies, and Specifications shall form the basis of the PLCs. Some status and analog points shall be displayed on more than one display screen, especially where it relates to more than one process or is significant to facility operations. Every analog and status value shall appear on at least one display screen. Analog values shall be displayed with appropriate engineering units.
- E. Selecting a flow meter, pressure sensor, and analyzer or level sensor shall open a pop-up trend of the last 24 hours for that instrument.
- F. Selecting a motorized valve shall open a pop-up palette with an valve control station interface. This station shall display the following:
 - 1. Auto/Manual control selection (if applicable)
 - 2. Manual Open-Stop-Close controls or position setpoint
 - 3. Local, Remote and Timeout Fail status
 - 4. Position feedback (as applicable)
- G. The following screen conventions shall be used:

1. Equipment that is running/open/remote shall be shown in RED with the word RUN/OPEN/REMOTE, respectively, next to it.
 2. Equipment alarm shall be shown in YELLOW with the word FAIL next to it.
 3. Equipment that is closed/not running/local shall be shown in GREEN with the word CLOSED/OFF/LOCAL, respectively, next to it.
- H. All Flow Totalizers, with the exception of the lifetime totalizer, shall be shown with Reset Buttons next to them.
- I. All unanimated objects shown for clarity shall be DARK GRAY.
- J. Properties for control system graphics and navigation shall be as determined by the final outcome of the Graphics Meetings.
- 3.03 PLC PROGRAMMING
- A. All PLC programming shall follow the AW Standards.
- 3.04 MEASUREMENT AND PAYMENT
- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 17910
PLC INPUT OUTPUT LIST

PART 1 GENERAL

1.01 SCOPE

- A. Provide and install the required hardware to monitor and control the input/output subsystem. The preliminary input/output lists are attached at the end of this section. Contractor shall coordinate with Owner and Engineer to verify all I/O physically at each site.
- B. The Contractor shall identify and document at the minimum the following:
 - 1. All existing cable termination points at the existing panel (ensure the length is adequate without any butt splices for terminal to PLC IO module).
 - 2. Functionality as well as electrical characteristic of each cable.
 - 3. Label each cable in preparation for the final panel transfer with understanding that any given site cannot be down for more than an 8 hour period.
- C. Based on the information above Contractor shall design all control panels per specification section 17400, and with minimal transfer time of PLC replacement.

1.02 SUBMITTALS

- A. Contractor shall submit an Input/Output list in Excel format, that includes PLC panel number, card and point location, configuration information, point description, point function and tag name.

PART 2 PRODUCT (NOT USED)

PART 3 EXECUTION

3.01 INPUT/OUTPUT LISTS

- A. Refer to the following sheets of this specification.

LPU-1 PLC IO LIST

Tag Name	Type	Address	Description	Note
AI_TC_LS_Lvl	AI	%IW0.2.0	Thickner Complex Lift Station Sump Level	Existing
AI_PST1_Lvl	AI	%IW0.2.1	Polymer Storage Tank 1 Level	Existing
TROUGH1_LEVEL_I	AI	%IW0.2.2	GBT 1 & 2 Trough Level	Remove
LIT-TC01-05	AI	%IW0.2.3	NPW Tank Level	Existing
SLP09_SPEED_CNTRL_O	AO	%QW0.2.4	GBT1-2 Sludge Discharge Pump 9 Speed Setpoint	Remove
SPARE	AO	%QW0.2.5	Spare	Existing
SPARE	AI	%IW0.3.0	Spare	
AI_PST2_Lvl	AI	%IW0.3.1	Polymer Storage Tank 2 Level	Existing
AI_PAT1_Lvl	AI	%IW0.3.2	Polymer Age/Mix Tank 1 Level	Existing
AI_PAT3_Lvl	AI	%IW0.3.3	Polymer Age/Mix Tank 3 Level	Existing
SPARE	AO	%QW0.3.4	Spare	Existing
SPARE	AO	%QW0.3.5	Spare	Existing
SPARE	AI	%IW0.4.0	Spare	
AI_PAT2_Lvl	AI	%IW0.4.1	Polymer Aging Tank 2 Level	Existing
AI_PAT4_Lvl	AI	%IW0.4.2	Polymer Aging Tank 4 Level	Existing
SPARE	AI	%IW0.4.3	Spare	Existing
SPARE	AO	%QW0.4.4	Spare	Existing
SPARE	AO	%QW0.4.5	Spare	Existing
HB-TC-PLC-001TIT	AI	%IW0.5.0	Thickener Complex PLC LPU1 Temperature	Existing
TIT-TC01-11	AI	%IW0.5.1	Centrifuge Electrical Room Temperature	Existing
TIT-TC01-12	AI	%IW0.5.2	GBT Electrical Room Temperature	Existing
TIT-TC01-13	AI	%IW0.5.3	Control Room Temperature	Existing
SPARE	AI	%IW0.5.4	Spare	Existing
SPARE	AI	%IW0.5.5	Spare	Existing
SPARE	AI	%IW0.5.6	Spare	Existing
SPARE	AI	%IW0.5.7	Spare	Existing
STAT_SLP9_On	DI	%IO.6.0	SLP 9 RUN Status	Remove
STAT_SLP9_Fail	DI	%IO.6.1	SLP 9 Fail Status	Remove
SPARE	DI	%IO.6.2	OLD - SLP No. 10 RUN Status	Remove
SPARE	DI	%IO.6.3	OLD - SLP No. 10 Fail Status	Remove
SPARE	DI	%IO.6.4	OLD - SLP No. 11 RUN Status	Remove
SPARE	DI	%IO.6.5	OLD - SLP No. 11 Fail Status	Remove
STAT_PMU1_Fail	DI	%IO.6.6	Polymer Makeup Unit No.1 FAIL Status	Existing
STAT_PST1_Low_Lvl	DI	%IO.6.7	Polymer Storage Tank No.1 Low Level	Existing

STAT_PMU2_Fail	DI	%I0.6.8	Polymer Makeup Unit No.2 FAIL Status	Existing
STAT_PST2_Low_Lvl	DI	%I0.6.9	Polymer Storage Tank No.2 Low Level	Existing
STAT_PRP1_On	DI	%I0.6.10	Polymer Recirc Pump No.1 RUN Status	Existing
STAT_PRP1_Fail	DI	%I0.6.11	Polymer Recirc Pump No.1 FAIL Status	Existing
STAT_PRP2_On	DI	%I0.6.12	Polymer Recirc Pump No.2 RUN Status	Existing
STAT_PRP2_Fail	DI	%I0.6.13	Polymer Recirc Pump No.2 FAIL Status	Existing
SPARE	DI	%I0.6.14	Spare	
HB-TC-PLC-001PWR_FAIL	DI	%I0.6.15	LPU1 Incoming Power Failure	Existing
SPARE	DI	%I0.7.0	Spare	Existing
SPARE	DI	%I0.7.1	Spare	Existing
STAT_NP1_On	DI	%I0.7.2	NPW Sump Pump 1 On	Existing
STAT_NP1_Fail	DI	%I0.7.3	NPW Sump Pump 1 Fail	Existing
STAT_NP2_On	DI	%I0.7.4	NPW Sump Pump 2 On	Existing
STAT_NP2_Fail	DI	%I0.7.5	NPW Sump Pump 2 Fail	Existing
STAT_NP3_On	DI	%I0.7.6	NPW Sump Pump 3 On	Existing
STAT_NP3_Fail	DI	%I0.7.7	NPW Sump Pump 3 Fail	Existing
STAT_Agitator1_Auto	DI	%I0.7.8	Polymer Age/Mix Tank No.1 Agitator Auto	Existing
STAT_Agitator2_Auto	DI	%I0.7.9	Polymer Age/Mix Tank No.2 Agitator Auto	Existing
STAT_Agitator3_Auto	DI	%I0.7.10	Polymer Age/Mix Tank No.3 Agitator Auto	Existing
STAT_Agitator4_Auto	DI	%I0.7.11	Polymer Age/Mix Tank No.4 Agitator Auto	Existing
STAT_Agitator1_On	DI	%I0.7.12	Polymer Age/Mix Tank No.1 Agitator Running	Existing
STAT_Agitator2_On	DI	%I0.7.13	Polymer Age/Mix Tank No.2 Agitator Running	Existing
STAT_Agitator3_On	DI	%I0.7.14	Polymer Age/Mix Tank No.3 Agitator Running	Existing
STAT_Agitator4_On	DI	%I0.7.15	Polymer Age/Mix Tank No.4 Agitator Running	Existing
STAT_TC_LSP1_On	DI	%I0.8.0	Thickener Complex Lift Station Pump 1 Running	Existing
STAT_TC_LSP1_Fail	DI	%I0.8.1	Thickener Complex Lift Station Pump 1 Fail	Existing
STAT_TC_LSP2_On	DI	%I0.8.2	Thickener Complex Lift Station Pump 2 Running	Existing
STAT_TC_LSP2_Fail	DI	%I0.8.3	Thickener Complex Lift Station Pump 2 Fail	Existing
STAT_TC_LSP3_On	DI	%I0.8.4	Thickener Complex Lift Station Pump 3 Running	Existing

STAT_TC_LSP3_Fail	DI	%I0.8.5	Thickener Complex Lift Station Pump 3 Fail	Existing
Alm_TC_LS_LVL_LOW	DI	%I0.8.6	Thickener Complex Lift Station Low Level	Existing
Alm_TC_LS_LVL_HIGH	DI	%I0.8.7	Thickener Complex Lift Station High Level	Existing
HB-TC-PLC-001UPS_BATT_FAIL	DI	%I0.8.8	Thickener Complex PLC LPU1 UPS Battery Fail	Existing
HB-TC-PLC-001PWR_FAIL	DI	%I0.8.9	Thickener Complex PLC LPU1 24Vdc Power Fail	Existing
HB-TC-PLC-001UPS_FAIL	DI	%I0.8.10	Thickener Complex PLC LPU1 UPS Fail	Existing
HB-TC-PLC-001INT_SW	DI	%I0.8.11	Thickener Complex PLC LPU1 Intrusion	Existing
HB-TC-CMP-001INT_SW	DI	%I0.8.12	Comm Rack Intrusion	Existing
HB-TC-LSH-001	DI	%I0.8.13	Centrifuge Discharge Trench Level High	Existing
HB-TC-FAN-011RUNNING	DI	%I0.8.14	GBT Electric Room Exhasut Fan 1 Running	Existing
HB-TC-FAN-012RUNNING	DI	%I0.8.15	GBT Electric Room Exhasut Fan 2 Running	Existing
CMD_PMU1_Start	DO	%Q0.9.0	Polymer Mix System No.1 Run Cmd	Existing
CMD_PMU2_Start	DO	%Q0.9.1	Polymer Mix System No.2 Run Cmd	Existing
CMD_Agitator1_Start	DO	%Q0.9.2	Polymer Age/Mix Tank No.1 Agitator Run Cmd	Existing
CMD_Agitator2_Start	DO	%Q0.9.3	Polymer Age/Mix Tank No.2 Agitator Run Cmd	Existing
CMD_Agitator3_Start	DO	%Q0.9.4	Polymer Age/Mix Tank No.3 Agitator Run Cmd	Existing
CMD_Agitator4_Start	DO	%Q0.9.5	Polymer Age/Mix Tank No.4 Agitator Run Cmd	Existing
CMD_Inlet_VLV_PAT1_Open	DO	%Q0.9.6	Polymer Age/Mix Tank No.1 Inlet Valve Open Cmd	Existing
CMD_Inlet_VLV_PAT3_Open	DO	%Q0.9.7	Polymer Age/Mix Tank No.3 Inlet Valve Open Cmd	Existing
CMD_Inlet_VLV_PAT2_Open	DO	%Q0.10.0	Polymer Age/Mix Tank No.2 Inlet Valve Open Cmd	Existing
CMD_Inlet_VLV_PAT4_Open	DO	%Q0.10.1	Polymer Age/Mix Tank No.4 Inlet Valve Open Cmd	Existing
CMD_Outlet_VLV_PAT1_Open	DO	%Q0.10.2	Polymer Age/Mix Tank No.1 Outlet Valve Open Cmd	Existing
CMD_Outlet_VLV_PAT3_Open	DO	%Q0.10.3	Polymer Age/Mix Tank No.3 Outlet Valve Open Cmd	Existing
CMD_Outlet_VLV_PAT2_Open	DO	%Q0.10.4	Polymer Age/Mix Tank No.2 Outlet Valve Open Cmd	Existing
CMD_Outlet_VLV_PAT4_Open	DO	%Q0.10.5	Polymer Age/Mix Tank No.4 Outlet Valve Open Cmd	Existing
SPARE	DO	%Q0.10.6	Spare	Existing

SPARE	DO	%Q0.10.7	Spare	Existing
CMD_Trough1_Low_Lvl_Shtdwn	DO	%Q0.11.0	Trough 1 Low Level Shutdown for SLP-9	Remove
HB_TC_CTF01_001_Lockout	DO	%Q0.11.1	Centrifuge No. 1 Lockout	Proposed
HB_TC_CTF01_002_Lockout	DO	%Q0.11.2	Centrifuge No. 2 Lockout	Proposed
HB_TC_CTF01_003_Lockout	DO	%Q0.11.3	Centrifuge No. 3 Lockout	Existing
HB_TC_CTF01_004_Lockout	DO	%Q0.11.4	Centrifuge No. 4 Lockout	Existing
HB_TC_CTF01_005_Lockout	DO	%Q0.11.5	Centrifuge No. 5 Lockout	Existing
SPARE	DO	%Q0.11.6	Spare	Existing
SPARE	DO	%Q0.11.7	Spare	Existing

3.02 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION

SECTION 17920

CONTROL NARRATIVE

PART 1 GENERAL

1.01 SCOPE OF WORKS

- A. This section describes work to be performed by the SCADA Programming Engineer. The Contractor is only responsible for items where noted.
- B. Configure, design, program and test the required process control logic that is defined in the provided Control Narrative.
- C. The developed programs and configuration shall meet the required operation and process control.
- D. All the developed programs, including PLC, OIU, existing SCADA programs and configuration shall be completely tested before the system field startup and commissioning.
- E. The following paragraphs are a general outline of the process control and operation.
- F. The City's SCADA Instrumentation Control Design Standards shall be followed in the PLC and existing SCADA configuration and programming. These documents are available upon request from the Owner.
- G. PLC programs shall be capable of functioning normally in the absence of OIU or existing SCADA without any special modifications. Process logic, including monitoring, control and alarming functions shall be programmed at the PLC level only.

Abbreviations used in this section:

ATS	Automatic Transfer Switch
A/M	Auto/Manual
DCS	Distributed Control System
GUI	Graphic User Interface
HMI	Human Machine Interface
HOA	Hand-Off-Auto
HOR	Hand-Off-Remote
LOR	Local-Off-Remote
L/R	Local/Remote
MCC	Motor Control Center
MCP	Master Control Panel
MMR	Motor Management Relay
OCA	Open-Close-Auto
OIU	Operator Interface Unit
OSC	Open-Stop-Close
PID	Proportional + Integral + Derivative
PLC	Programmable Logic Controller
PMU	Power Monitoring Unit

RVSS	Reduced Voltage Solid-State Starter
SCADA	Supervisory Control and Data Acquisition
S/S	Start/Stop
VCP	Vendor Control Panel (Supplied by Equipment Vendor)
VFD	Variable Frequency Drive
VSD	Variable Speed Drive

1.02 SUBMITTALS

1. Reference Section 17600

PART 2 REQUIREMENTS

2.01 GENERAL

- A. Shall coordinate with the SCADA Support Group to obtain the City's standard user-defined function blocks.
- B. PLC program shall use the City's preferred PLC programming language.
- C. Equipment tag name shall comply with the Owner's equipment identification naming convention. The Contractor shall coordinate with the Owner to obtain the equipment naming convention.
- D. The PLC Input/output list shall contain all items (Field, HMI, and Peer-to-Peer) to be configured for the point and shall be capable of being imported and exported into the system via an Excel spread sheet.
- E. The format of the Input/Output list shall follow the City SCADA I&C Standards. These documents are available upon request from the Owner.

2.02 PLC/SCADA CONTROL FUNCTIONS

- A. General: The SCADA shall display the status or value of all PLC input and output points and calculated points described in this section, detailed in the I/O schedule and shown on the P&ID drawings.
- B. Operator entered setpoints shall be constrained to match PLC programmed setpoint ranges. If a value lower than the setpoint range is entered, the PLC program shall default to the lowest possible range value. If a value higher than the setpoint range is entered, the PLC program shall default to the highest possible range value. PLC shall alert the operators of the valve being rejected.
- C. In general, confirmed PLC setpoint entries become the default program values. Should a PLC reboot occur, intended or uncontrolled event, the PLC program shall be automatically restored with last setpoint entries. No operator intervention shall be necessary to bring a freshly rebooted PLC online and operational.
- D. Fail Conditions: In addition to monitoring fail contacts for controlled equipment, if at any point a device fails to start, stop, open or close as commanded by the PLC, a timeout fail condition shall be generated by the PLC and displayed at the SCADA.

- E. Alarms related to SCADA displayed field equipment and facilities shall be displayed on the related system control screen as well as recorded in the historical alarm summary. Reference Specification Section 17520 for additional requirements.
- F. The entire system alarm history (read-only) shall be made accessible at the SCADA . Alarms shall be assigned to one of three (maximum) sub-groups. The alarm sub-groups shall be as defined at the conclusion of the project Graphics Meetings. An alarm configuration screen at the SCADA shall allow an authorized operator to enable or disable any SCADA alarm notification without the need to access the control system software configuration tools.
- G. Event Logging: An event log, separate from the alarm history, shall be made accessible at the SCADA (read-only). The event log shall date/time stamp and record any discrete change in status of the equipment monitored by the PLC (e.g. Local/Remote, Auto/Manual, Run/Off, Open/Close, Intrusion, Control Setpoint Change, Start Sequence Change, Alarm Enable/Disable, Out-of-Service status change, etc.). Events shall be assigned to one of four (maximum) sub-groups. The event sub-groups shall be as defined at the conclusion of the project Graphics Meetings.
- H. Loop tuning parameters: The SCADA interface shall be configured to allow operators with supervisory level security clearance, access to all loop tuning parameters from the SCADA for any control loop. Changing loop tuning parameters SHALL NOT require reconfiguring, reprogramming, or reloading of the PLC program. All changes to any loop tuning parameters shall be logged to the historical database event log.
- I. Equipment READY Logic: "Ready" shall be defined in the PLC program (if not already defined by field relay logic) as follows:
 - 1. Field equipment is currently in Remote and/or Auto mode (with LOS and/or disconnect switch disengaged).
 - 2. There are no fail conditions pending (including field E-Stop)
 - 3. The equipment is not currently in Run mode.
 - 4. No run inhibit conditions exist
- J. Ready shall be interpreted as "being available for remote (PLC and/or SCADA) operation". SCADA Manual and SCADA Auto mode cannot be achieved without the related equipment having a READY status. (Note: Once a run status is confirmed under this scenario, the equipment shall be noted to be running in Auto mode).
- K. Bumpless Auto/Manual Transition: Changing the SCADA Auto/Manual control status of controlled equipment shall be a bumpless operation. Therefore a motor operating in Auto mode at 78% of maximum speed shall maintain that speed and remain in operation when switched to manual control at the OIU. A similar adjustment to a modulating valve actuator should display identical behavior.
- L. Flow Signal Dampening: The PLC shall be programmed to dampen the incoming analog signal of all flow meters. This shall be accomplished by averaging the flow signal over a five second period. Specifically, the PLC shall sample the flow every half second for five seconds to calculate the average flow.

- M. Flow Totalization: The PLC shall be programmed to totalize flow volume. Volume shall be accumulated at a rate of once every five seconds. Flow totalization logic shall utilize dampened flow signals as described in paragraph H of this section.
- N. Runtime and Number of Starts: The PLC shall be programmed to calculate all motor runtimes and display the value in tenths of an hour on the SCADA . A lifetime runtime and a resettable/pre-settable runtime shall be provided for each distribution pump. The PLC shall be programmed to calculate the number of starts and display the value on the SCADA . A lifetime number of starts and a daily number of starts shall be provided for each distribution pump.
- O. Out of Service: The control system shall have the facility to assign an "Out-of Service" tag to equipment monitored by the control system or to the entire pump station facility. During extended periods of maintenance and/or repair, an operator may make such an assignment so as to suppress associated alarms and inhibit OIU/PLC control functions.
- P. Control Strategy Refinement: It shall be understood that some refinement and/or minor modification of the control strategies shall be necessary over the course of the project at no additional cost. Forums for informal discussions and clarifications have been provided in these documents. They include the Presubmittal Conferences, Graphics/Reports Development meetings, Factory Testing, Field Development Phase and Startup. Note: All timer, level, position, analysis and flow rate values noted within the control strategies are provided for reference only and are subject to change based on final construction.
- Q. Standard AWU Function Blocks: The SCADA Programming Engineer shall use standard AWU function blocks in all instances where a standard function block has been defined and is currently in use by the Owner. AWU standard function blocks which have been developed in the Modicon Concept development package shall be converted to Modicon Unity for this project.
- R. AWU Programming Standards: The SCADA Programming Engineer shall follow all established AWU programming standards. These standards shall be provided to the SCADA Programming Engineer by the OWNER after the contract is rewarded. The Engineer shall receive a current version from the OWNER after the contract is awarded.

PART 3 EXECUTION

3.01 CONSTRUCTION SEQUENCE

- A. Refer to specification 01015 Sequence of Construction for LPU-1 PLC replacement construction sequence.

3.02 CONTROL NARRATIVES – PLC LPU-1

- A. The LPU-1 PLC program shall be reused for the Phase 2 project.
- B. The existing equipment PLC program and memory map for SCADA communication shall not changed in the new PLC. After PLC program is reloaded in the new PLC. SCADA Programming Engineer shall verify and test all existing program with SCADA system.

This includes equipment reading SCADA HMI displays and equipment SCADA HMI control.

- C. Delete this project demolished GBT No. 1/2 and other equipment PLC program and SCADA configuration. Label the demolished equipment PLC inputs and outputs as spare. Delete SCADA database demolished equipment database and displays, alarm and other configuration.
- D. Program polymer system interlock with centrifuge No. 1 and 2 function in the PLC.
- E. Program centrifuge No. 1 and 2 power meter GE PQM reading for SCADA monitoring.

3.03 CONTROL NARRATIVES – SCADA HMI

- A. Configure and program SCADA HMI to monitor centrifuge No. 1 and 2. Provide SCADA HMI monitor and control of centrifuge No. 1 and 2. All new screens for centrifuge 1 and 2 shall use existing centrifuge screen layout.
- B. Update the centrifuge system overview screen by replacing GBT 1 and 2 with centrifuge 1 and 2.
- C. Delete GBT No. 1 and 2 database and HMI screens.
- D. Configure and program centrifuge No. 1 and 2 alarm and events.
- E. Configure and program centrifuge No. 1 and 2 historian and trending.

3.04 MEASUREMENT AND PAYMENT

- A. All work items installed, provided, constructed, etc. with the exception of the unit price items listed in the 300L, shall not be paid for separately but shall be considered subsidiary to the lump sum bid price for the Project. The cost of all work materials, labor, overhead, insurance, equipment, etc. necessary to finish the work complete in place shall be included in the lump sum bid price for the project.

END OF SECTION